Annual Progress Report
Lower Snake River Compensation Plan
Confederated Tribes of the Umatilla Indian Reservation
Evaluation Studies for 1 January 2017 to 31 December 2017

Evaluation of Reestablishing Natural Production of Spring Chinook Salmon in Lookingglass Creek, Oregon, Using a Local Stock (Catherine Creek)

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1.1 Abstract

The objective of this study is to evaluate the reintroduction of a local hatchery-origin spring Chinook salmon stock in Lookingglass Creek using standard sampling methods for anadromous salmonids in the Columbia River Basin. Total returns to the Lookingglass Hatchery trap in 2017 were 296, of which 43 were natural-origin. Releases above the Lookingglass Hatchery weir totaled 90 and spawning ground surveys yielded 32 redds above the weir, and 68 below. Brood year 2012 recruits per spawner was 0.5 for adults only. We estimated 26,502 (143 outmigrants/redd) brood year 2015 juveniles outmigrated from above Lookingglass Hatchery during migration year 2017. Survival probabilities to Lower Granite Dam ranged from 0.146-0.515 for summer, fall, winter, and spring PIT-tagged groups. Smolt equivalents (outmigrants surviving to Lower Granite Dam) totaled 5,464. Brood year 2012 smolt-to-adult ratio was 4.4 for adults only. Harmonic mean travel time (in days) to Lower Granite Dam for brood year 2015 was 269, 229, 191, and 60 for summer, fall, winter, and spring groups, respectively.

1.2 Introduction

This is the latest in the series of annual progress reports documenting the reintroduction of spring Chinook salmon to Lookingglass Creek, tributary to the Upper Grande Ronde River in the Snake River Basin in northeastern Oregon (Figure 1). Many stocks of anadromous salmon in the Columbia River Basin have experienced severe declines in abundance or become extirpated over the last several decades (Nehlsen, et al., 1991). Hatcheries were built in Oregon, Washington and Idaho under the LSRCP to compensate for the loss of anadromous salmonids due to the construction and operation of the four Lower Snake River dams. The endemic Lookingglass Creek (LGC) stock of spring Chinook salmon was extirpated within a few years after establishment of Lookingglass Hatchery (LH) in 1982. No fish had intentionally been released upstream of the LH weir since the construction of the hatchery, with the exception of a few fish in 1989. The Confederated Tribes of the Umatilla Indian Reservation (CTUIR), along with comanagers Oregon Department of Fish and Wildlife (ODFW) and the Nez Perce Tribe (NPT), began work in the early 1990's to reestablish natural production of spring Chinook salmon in LGC. Lookingglass Creek was chosen as a good location to evaluate such a study due to the existence of a weir, quality habitat, and an existing dataset from the endemic era population (Lofy & McLean, 1995). Several stocks, including remnants of the LGC endemic stock, Imnaha River, Wind River (Washington), Carson Hatchery (Washington), and Rapid River (Idaho) were all used before comanagers settled on Rapid River stock. This study continued through the mid and late 1990's, until co-managers decided that adults should not be released upstream of the weir due to potential increases in pathogens in the water supply. This stock was phased out, and was later replaced with Catherine Creek (CC) captive brood stock (Gee, et al., 2014) progeny as the initial donor stock. This stock was chosen since CC stock are native to the Grande Ronde Subbasin and had similar habitat and attributes to LGC. The first CC juvenile hatchery-reared release occurred as pre-smolts in September 2001, and the first adult releases upstream of the LH weir occurred in 2004. CC hatchery-origin (HOR) spring Chinook salmon have spawned successfully in nature, produced outmigrants, and these outmigrants have returned as adults to LGC. The first naturally produced returns occurred in 2007 as jacks and the first complete brood year occurred in 2009. Current management practices include the release of both HOR and natural-origin (NOR) returns to spawn in nature above the LH weir, and the use of both HOR and NOR returns in a conventional brood stock program at LH. Annual reports describing past progress in reestablishing natural production of spring Chinook salmon in LGC are listed in the Literature Cited of this Section.

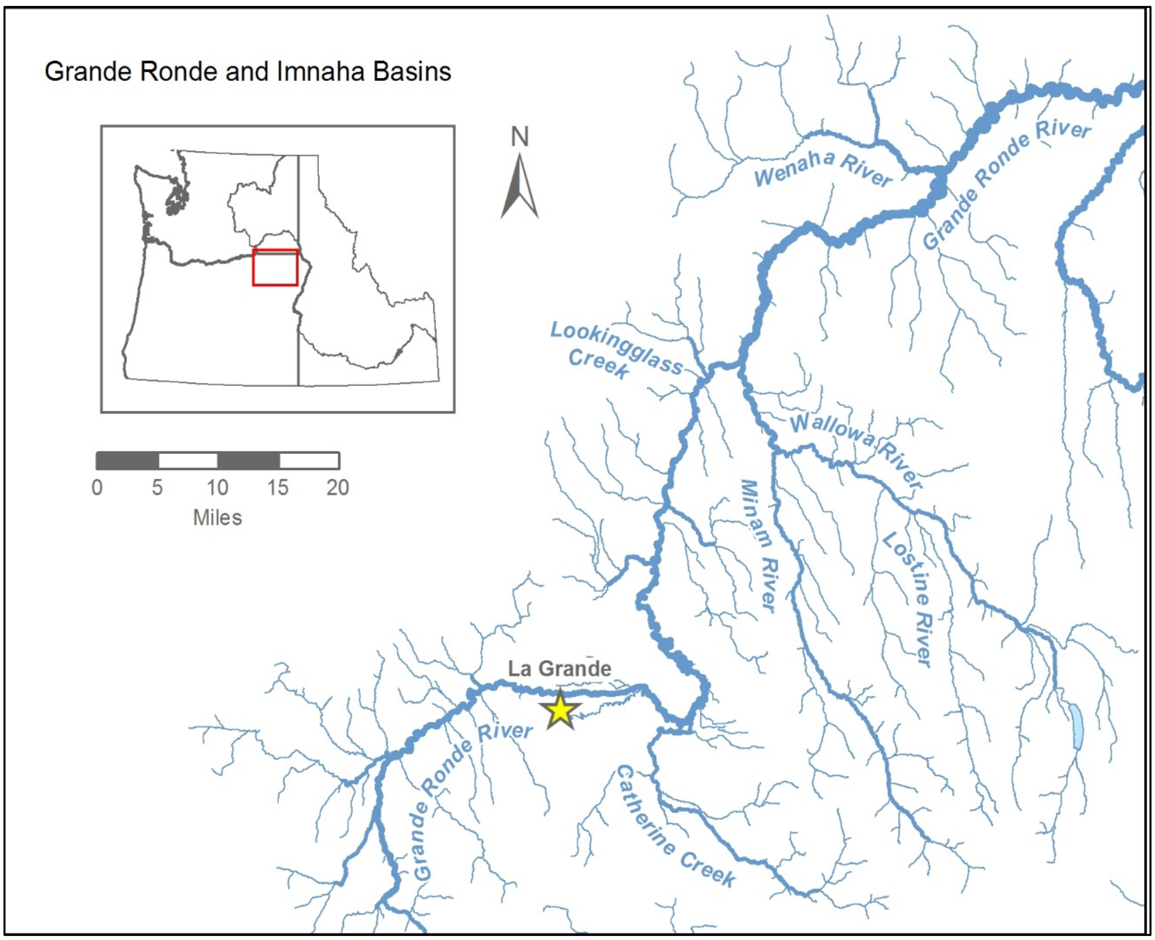

Figure 1. Location of Lookingglass Creek and the Grande Ronde Basin.

The CTUIR project goals are to evaluate the reintroduction of spring Chinook salmon into LGC using the CC stock, increase tribal harvest, and maintain a gene bank for the CC donor stock. LGC is within the usual and accustomed areas of gathering for the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) under the Treaty of 1855

(Gildemeister, 1998). The CTUIR focuses on reestablishment of the natural population above the LH weir and ODFW on the hatchery component (Feldhaus, et al., 2011). Using the natural component of LGC fish, the CTUIR will study status and trends based on the Viable Salmonid Population metrics of abundance, population growth, spatial distribution and diversity. Metrics for abundance include total returns of adults, hatchery vs natural proportions, sex ratios, redd counts, and juvenile outmigrant estimates. Metrics evaluated for population growth include Recruits per Spawner, smolt-to-adult-returns (SAR's), and juvenile survival to the dams. Spatial distribution includes redd distribution and juvenile rearing. Genetic diversity is monitored with tissue analyses, to include an ongoing relative reproductive success study (CRITFC), as well as looking at age structure, migration and spawn timing, and juvenile emigration. All of these metrics will be outlined and discussed in this report.

1.3 Program Objectives

The goal of the LGC Spring Chinook Hatchery Program is to reintroduce spring Chinook into LGC using the CC stock to support tributary harvest, natural population restoration, and maintenance of a gene bank for the CC stock (ODFW, 2011).

Program specific objectives stated in the Hatchery and Genetic Management Plan (HGMP) for the LGC program include:

1. Restore and maintain viable naturally spawning populations of Chinook salmon in LGC.
2. Contribute to recreational, commercial and tribal fisheries in the mainstem Columbia River consistent with agreed abundance based harvest rate schedules established in the 2008 – 2017 *U.S. vs. Oregon* Management Agreement.
3. Establish adequate broodstock to meet annual production goals.
4. Establish a consistent total return of Chinook salmon that meets the LSRCP mitigation goal. There are no LSRCP or Tribal Recovery Plan (TRP) hatchery and natural adult return goals identified specifically for LGC. However, LSRCP does have a specific spring/summer Chinook goal of 58,700 hatchery adults for the Snake River and 5,820 hatchery adults into the Grande Ronde Basin. The TRP return goal for the Grande Ronde Basin is 16,000 adults.
5. Re-establish historic tribal and recreational fisheries.
6. Minimize impacts of hatchery programs on other indigenous species.
7. Operate the hatchery program so that the genetic and life history characteristics of hatchery fish mimic those of natural fish, while achieving mitigation goals.

This project is guided by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) Department of Natural Resources (DNR) Mission Statement (Jones, et al., 2008)

"To protect, restore, and enhance the First Foods - water, salmon, deer, cous and huckleberry – for the perpetual cultural, economic and sovereign benefit of the CTUIR. We will accomplish this using traditional ecological and cultural knowledge and science

to inform: 1) population and habitat management goals and actions; and 2) natural resource policies and regulatory mechanisms.

and the CTUIR Department of Natural Resources, Research, Monitoring and Evaluation Mission Statement:

> ***"Generate knowledge regarding the biological performance and ecology of aquatic species of the first food order in a scientifically credible and policy relevant manner to inform management and policy decisions."***

1.4 Study Area

Lookingglass Creek originates at Langdon Lake in the Blue Mountains of northeast Oregon at an elevation of 1,484 m above sea level. Gradient is approximately 3% and flow is to the southeast for 25 river km (rkm) through a relatively steep walled canyon within the Umatilla National Forest. The creek then flows through private land with a comparatively wider floodplain for approximately 2.7 km before entering again a narrow canyon down to the Grande Ronde River at rkm 137 (718 m above sea level). A 27-year dataset showed mean monthly flows ranging from 1.5-2.3 m^3/sec during the base flow period of July-December to 9.5-11.2 m^3/sec during spring runoff in April and May. Peak flow during this period was recorded in 1996 at 60.0 m^3/sec. LGC stream flow information was collected by electronic data recorders operated by the U. S. Geological Survey near LH from August 1982-September 2009 (http:/nwis.waterdat.usgs.gov).

One major tributary (Little Lookingglass Creek, rkm 6.4) and four smaller tributaries (Lost Creek, rkm 17.3; Summer Creek, rkm 16.5; Eagle Creek, rkm 13.3: and Jarboe Creek, rkm 3.6) contribute to LGC (Figure 2). All or nearly all spring Chinook spawning occurs in LGC and Little Lookingglass Creek (LLGC). LH is located from rkm 3.6 to 4.1 on LGC. Upstream migration of returning adult spring Chinook salmon is controlled by the LH weir and trap at rkm 4.1.

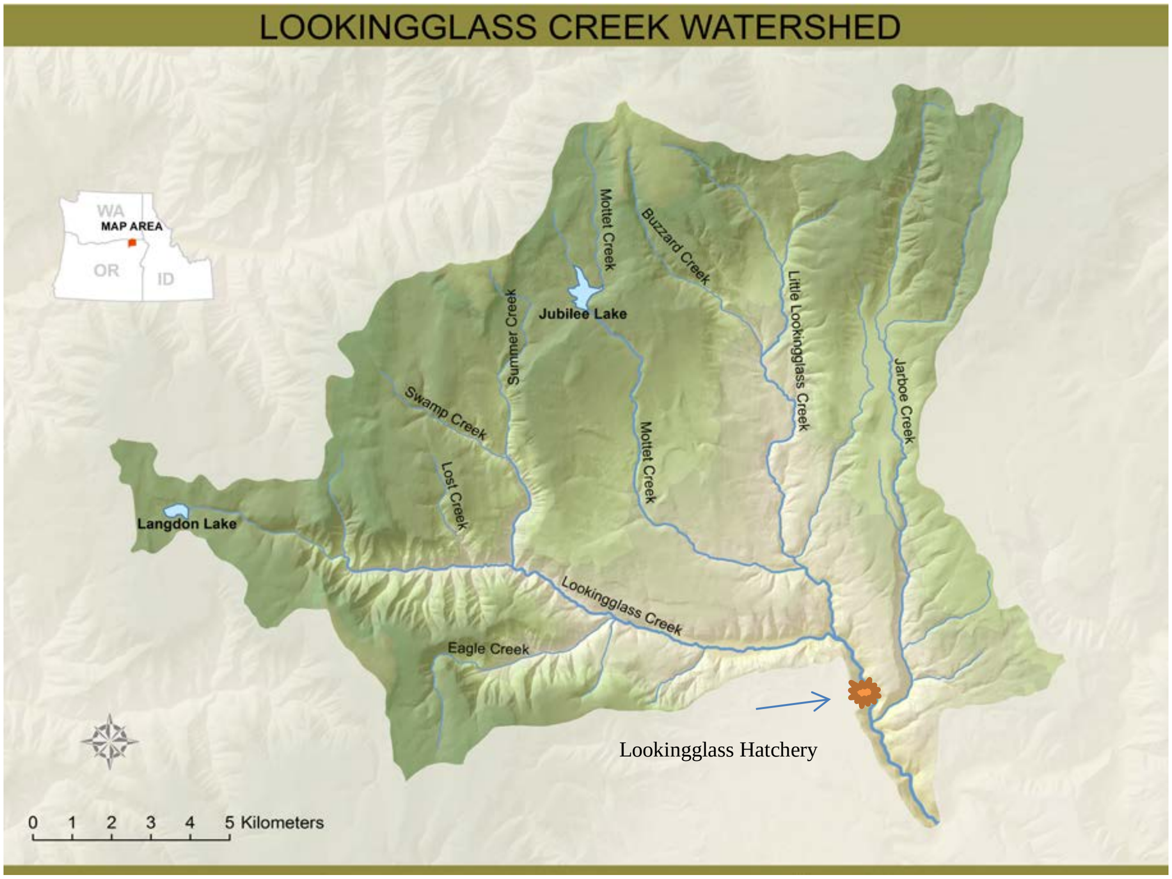

Figure 2. Lookingglass Creek watershed showing major and minor tributaries.

1.5 Methods

1.5.1 Adult Spring Chinook Salmon

Adult Returns to the LH Weir

Adult spring Chinook salmon returning to LGC are diverted by a picket weir into a trap near the LH water intake (Figure 3). ODFW LH staff installs and operate the picket weir and trap annually from 1 March through mid-September. The trap is checked at least 3 times (Monday, Wednesday, Friday) weekly. ODFW LH staff record catch data and these are reported in detail in annual reports for the Spring Chinook Salmon Evaluation Studies, available at http://www.fws.gov/lsnakecomplan/Reports/ODFWreports.html.


Figure 3. Lookingglass Hatchery adult trap located at rkm 4.1.

Adult spring Chinook salmon captured in the LH trap in 2017 could have been from several sources: LGC natural production above or below the LH weir, hatchery-reared Catherine Creek (CC) captive broodstock progeny released into LGC, or hatchery or naturally reared returns from other Grande Ronde Basin stocks (including Upper Grande Ronde River stocks) that have strayed from other streams. Disposition of returns is determined based on a sliding scale (Section 1.7 of this report). Adult NOR and HOR returns were either passed upstream to spawn in nature or held for broodstock needs. Adults are classified as fish ages 4 and 5 (≥601mm) and jacks as age 3 (≤ 600 mm). In years where there are surplus HOR jacks, they may be sacrificed and provided to the local food bank or for ceremonial subsistence, or recycled downstream of the LH weir to supplement the fishery. No HOR jacks have been intentionally placed upstream of the weir since 2012.

Releases Above the LH Weir

In 2017, fish were released just upstream of the LH weir in the deep pool near the water intake building (Figure 4). All fish released above the weir were measured (mm FL), sexed, scanned for PIT tag, and a small amount of tissue from the right opercle was removed with a round paper punch and placed in Rite in the Rain envelopes for later genetic analysis. The presence or absence of these opercle punches were also used to distinguish any spawners above the weir that were not handled at the trap and for estimating the spawning population. Scales were collected and used to make age determinations for a portion of the NOR returns passed above the weir. Ages for a portion of the HOR returns were determined by Coded Wire Tag (CWT) data from the Regional Mark Information System (RMIS) database maintained by the Pacific States Marine Fisheries Commission (http://www.rmpc.org/). These CWT were obtained posthumously on spawning surveys.

Figure 4. Lookingglass Hatchery return tube constructed by ODFW and CTUIR which allows fish to be released directly into the stream after handling. Pipe has running water, a gradual slope, and releases fish into a deep pool (arrow).

Spawning Ground Surveys

Spawning ground surveys were conducted using similar methods as (Parker, et al., 1995) and (Crump & Van Sickle, 2016) during August-September 2017 to assess the temporal and spatial distribution of natural spawning. Several pre-spawn mortality surveys are also conducted in July and early August to collect carcass information and determine when the first redd is observed. Surveys were conducted in all 5 stream units each week after the first redd was observed (Figure 5). Only completed redds were counted, flagged, and a GPS point taken to eliminate double counting (Lofy & McLean, 1995), (Crump & Van Sickle, 2016).

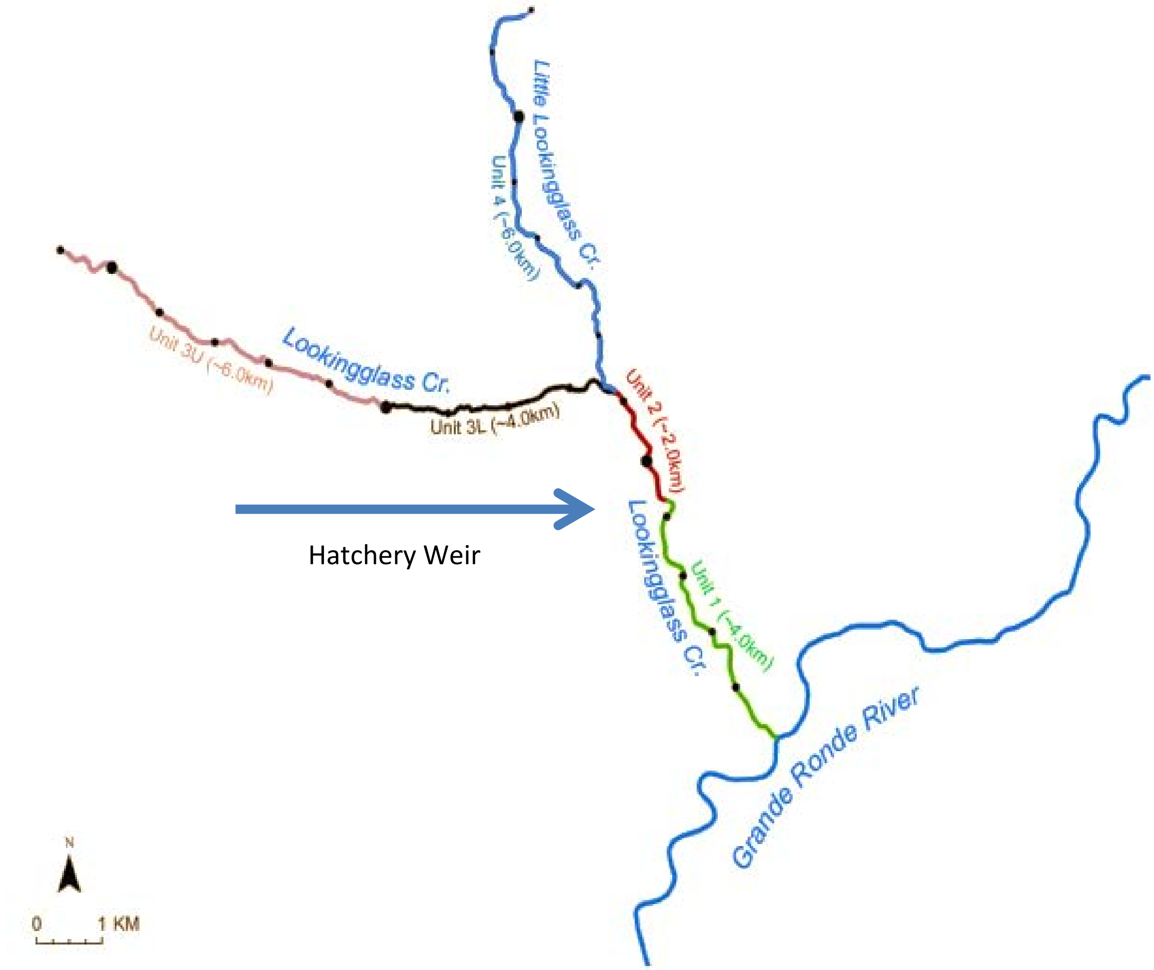

Figure 5. Lookingglass Creek section breaks for spawning surveys. Unit 1 is below the weir, while all other units are above.

Carcass Recoveries

Carcasses were enumerated and FL (mm), sex, marks, and percent spawned is recorded for females. Females that had spawned $\leq$ 50% were considered pre-spawn mortalities. Tails were cut off all handled carcasses to prevent double sampling in the subsequent weeks. Snouts were taken from all carcasses with a CWT present. Above the weir this should only be on fish with an existing Adipose clip, however below the weir this could also include unclipped fish that have strayed from the Upper Grande Ronde. CWT data are used for determining strays that spawned above and below the weir in addition to identifying the age of the fish. Kidney samples were taken from a portion of the carcasses to determine incidence of bacterial kidney disease (O'Connor & Hoffnagle, 2007).

Population Estimate and Spawner Estimate Above the Weir

Population estimates of fish above the LH weir were made for fish $\leq$ 600 mm FL (jacks) and $\geq$ 601mm (age 4, 5 adults) using the Chapman modification of the Petersen method (Ricker, 1975). Fish marked with an ROP recovered below the picket weir were removed from the total numbers of fish released, as these appeared to have fallen back and did not contribute to spawning in reaches upstream of the weir.

The standard error of the mean was calculated as follows:

$$SEM = \sqrt{\frac{(M)(n)(M-R)(n-R)}{R^3}}$$

M=Number of marked fish released above the weir, n=Number of carcasses recovered above the weir, R=Number of punched/marked carcasses recovered (Brower, 1977).

The spawner estimate above the weir is typically obtained by multiplying the percent of female pre-spawn mortality recoveries (those $\leq$50% spawned out) on spawning ground surveys to the population estimate above the weir. However, in 2017, so few carcasses were recovered above the weir that it did not provide an accurate assessment of pre spawn mortality. Thus, an average of all of the years since the reintroduction began (2004-2016) was used as the percent of pre-spawn mortality (Joseph Feldhaus-Oregon Department of Fish and Wildlife, personal communication 2017).

Recruits/Spawner
Recruits per spawner is calculated by dividing the total number of spawners (HOR and NOR) estimated to be above the weir for a given BY, by the total number of NOR offspring returning as adults to LGC weir for the completed BY.

1.5.2 Juvenile Spring Chinook Salmon

Outmigrants
We operated a 1.52 m diameter rotary screw trap at rkm 4.0 on LGC, which is 0.1 rkm below the LH adult trap (Crump, 2010). The rotary trap captures outmigrating naturally-produced juvenile spring Chinook salmon, as well as O. *mykiss*, dace, sculpin, and bull trout (Figure 6). Trap operation was suspended during high spring freshets, midsummer during low flows when temperatures were high and also when iced up in winter. Except for the spring freshet, these are periods when there are historically few outmigrants. We made no attempt to estimate outmigrants during these periods. The trap was checked three times per week or more frequently if catches or flows were high. All outmigrants were identified, counted, examined for external marks, and scanned for PIT tags. A portion of these were also PIT tagged, measured (nearest mm FL), and weighed (nearest 0.1 g) each week. Only Chinook over 60mm were PIT tagged and used for trap efficiency estimates. Fish were PIT tagged using a 10 ml hand held syringe, while inserting the tag on the belly of the fish (PIT Tag Steering Committee, 1999). These PIT tagged fish were released about 100m above the trap. All other fish (counted, measured, recaptures, fry, precocials) are released below the trap (Crump, 2010).


Figure 6. Rotary screw trap located at rkm 4.0 on Lookingglass Creek.

Outmigrant Estimate

We used DARR 2.9.1 (Bjorkstedt, 2008) to estimate the numbers of outmigrants. DARR 2.9.1 uses stratified mark-recapture data and pools strata with similar capture probabilities. Darr calculates an estimate by using the total number of first time captures, the total number of marked individuals, and the recaptures of those marked fish over the migration period. We used the “one trap” and “no prior pooling of strata” options available in Darr. Outmigrants collected at the screw trap could be distinguished into brood years based on marks or size. Some BY 2015 fry or small parr were caught during January-June of 2016 and were not marked or used in trap efficiency or outmigration estimates. The fall group of NOR BY 2015 fish was caught, PIT-tagged and released from 1 July-30 September 2016, the winter group from 1 October-31 December 2016, and the spring group from 1 January-30 June 2017. Metrics are described by Hesse et al. (2006) and correspond to the basic categories of abundance, productivity, and diversity for viable salmonid populations (McElhany, et al., 2000).

Survival Estimates

We estimated survival, capture probability, and travel time using the Pacific States Marine Fisheries Commission PIT tag database at http://www.ptagis.org/ and PitPro (Westhagen & Skalski, 2009). We used the standard configuration in PitPro, excluded the *.rcp file, and included the *.mrt file. Observation sites, in downstream order, were Lower Granite Dam, Little Goose Dam, Ice Harbor Dam, Lower Monumental Dam, McNary Dam, John Day Dam, The Dalles, and Bonneville Dam. Bonneville Dam was selected as the last recapture site. Smolt equivalents for BY 2015 natural production above the weir were calculated as the number of outmigrants per season (fall, winter, spring) multiplied by each seasonal survival estimate to Lower Granite Dam.

SAR's

Smolt to Adult Returns (SARs) are calculated as the number of returning NOR adults to the weir from a given BY divided by the estimate of outmigrating smolts surviving to LGD (S_{eq}) for that BY.

Monthly Sampling

We monitored seasonal growth of naturally-produced BY 2015 spring Chinook salmon by obtaining fork lengths (mm) and weights (+/- 0.1 g) of 50 fish collected by snorkel/seining at several locations above the LH adult trap (rkm 8.9, and 10.5) on the 20th (+/- 5 d) of July, August, September and October 2016. Burck (1993) used similar methods to describe growth of juvenile spring Chinook salmon during the endemic era (1964-1970) and also sampled juveniles at rkm 8.9.

Precocials

We capture a small amount of precocial Chinook salmon in the rotary screw trap each year, usually during the August and September months when adult Chinook are spawning. We also capture a small number during our monthly sampling and summer parr sampling efforts (described below). We take fork length and weights, as well as genetic samples from these fish, so that their contribution to the population can be identified from the relative reproductive success study that is ongoing.

Summer Parr Sampling

We target approximately 1,000 BY 2015 parr using snorkel/seine methods from the primary rearing area (rkm 8.9- 12.0) above LH in early August 2016. A remote station was set up at rkm 10.0 to process these fish. These fish were PIT-tagged using standard procedures (PIT Tag Steering Committee, 1999) and released back to site of capture. Recaptures in the screw trap of these PIT-tagged parr (referred to later in document as summer group) were not reused for trap efficiency but counted as unmarked first time captures and released below the screw trap.

1.5 Results/Discussion

1.5.1 Adult Abundance

Returns to the LH weir

There were a total of 253 HOR and 43 NOR returns to the LH weir in 2017. There was no unpunched NOR carcasses recovered above the LH weir, which would have indicated that they had escaped past the weir without handling. In general, we have seen an upward trend in our NOR returns. However, run year 2017 marked one of the worst returns since the reintroduction began (Table 1). Conversely, when looking at completed BY returns, the NOR returns for BY 2012 were 370, the highest since the beginning of the current reintroduction era. In direct correlation, redd numbers above the weir for BY 2012 were also the highest since reintroduction efforts began (n=314). The estimated age composition based on fork length of NOR returns to the LH trap were 15 (35%) age 3, 18 (42%) age 4, and 10 (23%) age 5 (Table 1). Age composition of NOR returns in past years has been dominated by age 4, but substantial numbers of age 3 returns occurred in 2009-2011 and 2013-2015. In 2013, age 3 NOR returns surpassed both age 4 and 5 returns combined. These low returns tabulated in 2013 (n=119) are likely having an adverse effect on the age 4 returns in 2017 (n=18).

Table 1. NOR returns to the LH weir for each Run Year (RY), and by completed Brood Year (BY) with age based on fork length.

Returns by RY					Returns by Completed BY				
	Age					Age			
RY	3	4	5	Totals	BY	3	4	5	Totals
2007	7			7	2004	7	46	9	62
2008	4	46		50	2005	4	69	9	82
2009	24	69	9	102	2006	24	124	14	162
2010	17	124	9	150	2007	17	120	15	152
2011	30	120	14	164	2008	30	129	12	171
2012	3	129	15	147	2009	3	47	14	64
2013	60	47	12	119	2010	60	174	11	245
2014	35	174	14	223	2011	35	228	26	289
2015	35	228	11	274	2012	35	325	10	370
2016	6	325	26	357					
2017	15	18	10	43					

Releases above the LH weir

During the early years (2004-2006) of the current reintroduction era, small numbers were released above the LH weir (Figure 7). In 2012 and 2015, the current reintroduction era numbers released above the weir surpassed the endemic study era high of 727, with 926 and 769 respectively. Prior to 2017, the population had appeared to be on an upward trend. There were 62 HOR and 28 NOR passed above the weir in 2017, for a total of 90 (Figure 8). The majority of the remaining returns were taken in an attempt to meet broodstock needs, however this number was not met. Of the 62 HOR released upstream, all were estimated as age 4 and 5 adults. In 2017, HOR jacks totaled 110, of which 12 were kept for broodstock and the remaining 98 were provided for food bank and ceremonial subsistence (ODFW, unpublished data). Of the 28 NOR Chinook passed upstream, 13 were estimated as adults and 15 as jacks. Therefore in 2017, 54% of NOR fish released above the weir were jacks. There were a total of 40 females released, which were 85% HOR.

The sex ratio above the weir has been kept very near 1:1 for most years (Figure 9). HOR fish were 100% of the adults released above the LH weir in 2004-2006. Since then, HOR adult releases have ranged from 39% to 90%, with an average over those 8 years of 71%. While we do release some NOR jacks upstream to spawn naturally, beginning in 2012 no HOR jacks have been intentionally released upstream of the LH weir.

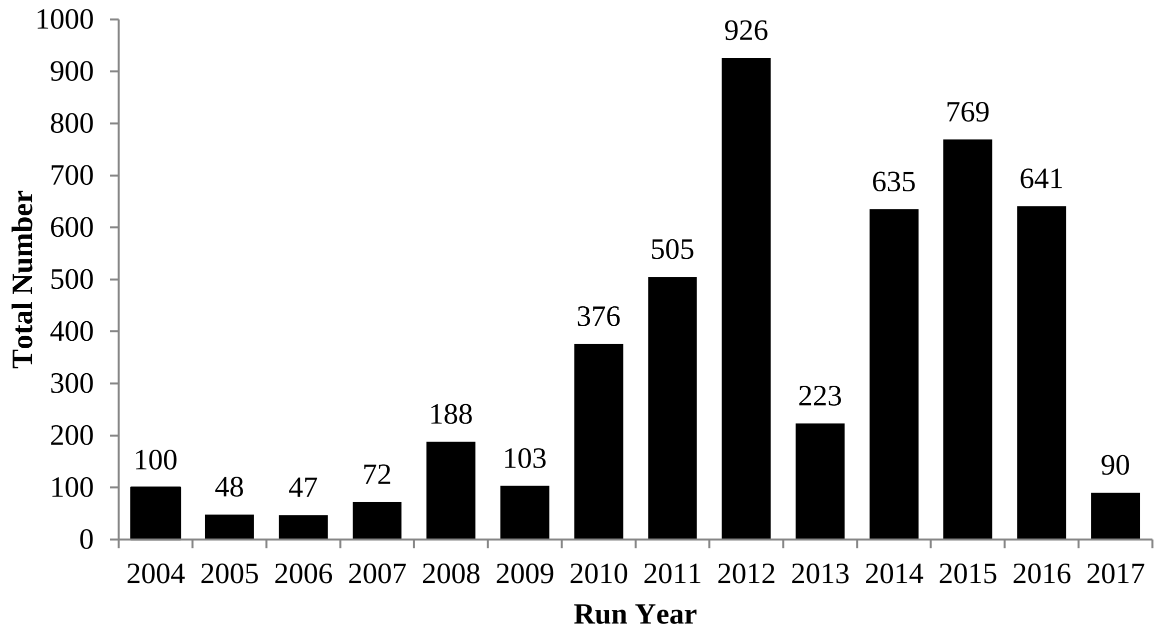

Figure 7. Lookingglass Creek spring Chinook salmon total releases above the weir, RY 2004-2017. Includes all ages, hatchery and natural origin.

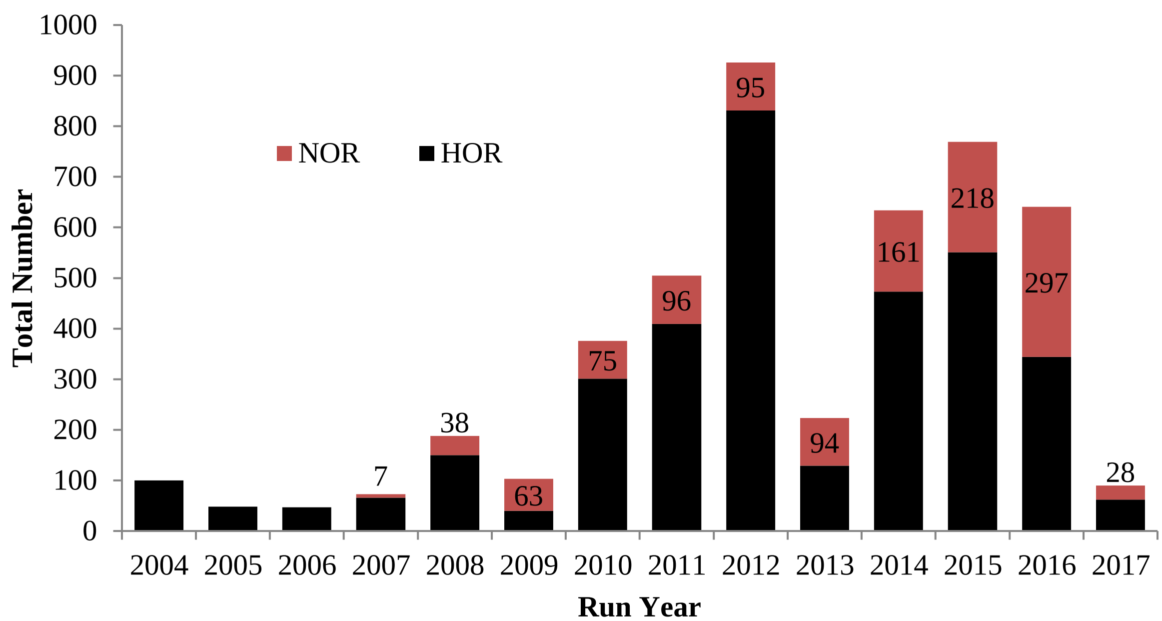

Figure 8. Lookingglass Creek spring Chinook HOR vs NOR returns, RY 2004-2017.

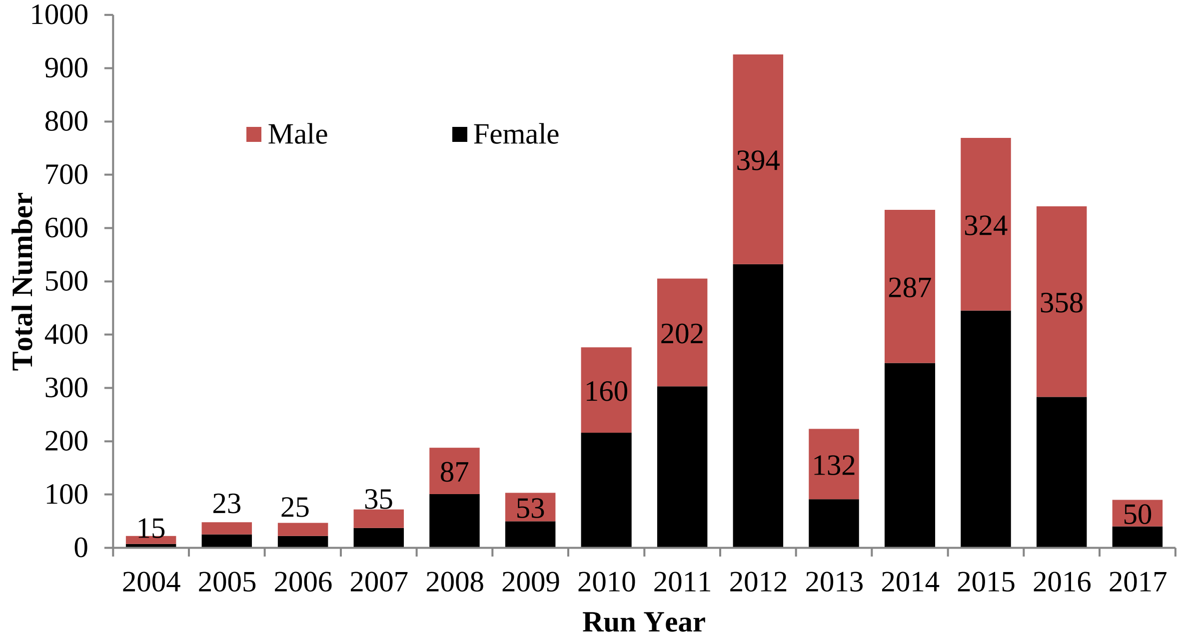

Figure 9. Lookingglass Creek spring Chinook salmon Male vs Female releases above the weir, RY 2004-2017. In 2004, 78 HOR adults were hauled from Catherine Creek and released upstream since there were not enough NOR returns. These 78 fish were excluded due to lack of data on sex ratios.

Spawning Ground Surveys

We completed 22 spawning ground surveys on LGC during 14 August-12 September and observed, flagged, and took GPS coordinates on a total of 100 Chinook redds (Table 2). The first completed redds were observed on 14 August on Unit 1 below the LH weir. This was unusual to observe the first redd so low in the system. Typically, a general pattern of redds being constructed in the upper reaches of Unit 3U and 3L occur first, and then move downstream to the lower reaches as the season progresses. There were a total of 32 Chinook redds observed in Units 2, 3L, 3U, and 4 above the LH weir and 68 in Unit 1 below the weir. Redds in Units 3L and 3U made up 81% of all redds observed above the LH weir in 2017. This percent has ranged from 63-94% since 2004. However, it is of note that only 32% of the total redds occurred above the weir this year (18km of spawning habitat), while 68% occurred below (4km of spawning habitat). Peak numbers of new redds observed above LH weir were between 24 August and 7 September, while the peak numbers observed below the LH weir was from 25 August to 31 August.

Table 2. New redds observed on surveys of LGC by work week and by unit, RY 2017.

	Unit				
Period	1	2	3L	3U	4
8/14-8/18	3	0	1	0	0
8/21-8/25	21	3	3	1	1
8/28-9/1	34	1	8	3	0
9/4-9/8	6	1	7	3	0
9/11-9/15	4	0	0	0	0
Totals	68	5	19	7	1
2017 Percentage by unit (%)	68	5	19	7	1
2004-2017 Percentage by unit (%)	37	7	21	28	7

With approximately 4.0 rkm of available spawning habitat below the weir, the redds/per km is much higher and redds are often superimposed over one another (Figure 10). In some years (2010 and 2012), outplants from CC have been placed below the weir in LGC to supplement the fishery and these fish may also spawn in Unit 1. There were several areas upstream of the weir with medium densities of redds in Units 3L and 3U. The smaller numbers of redds observed in Unit 2 and 4 (LLGC) may be due to less spawning gravel and higher gradients.

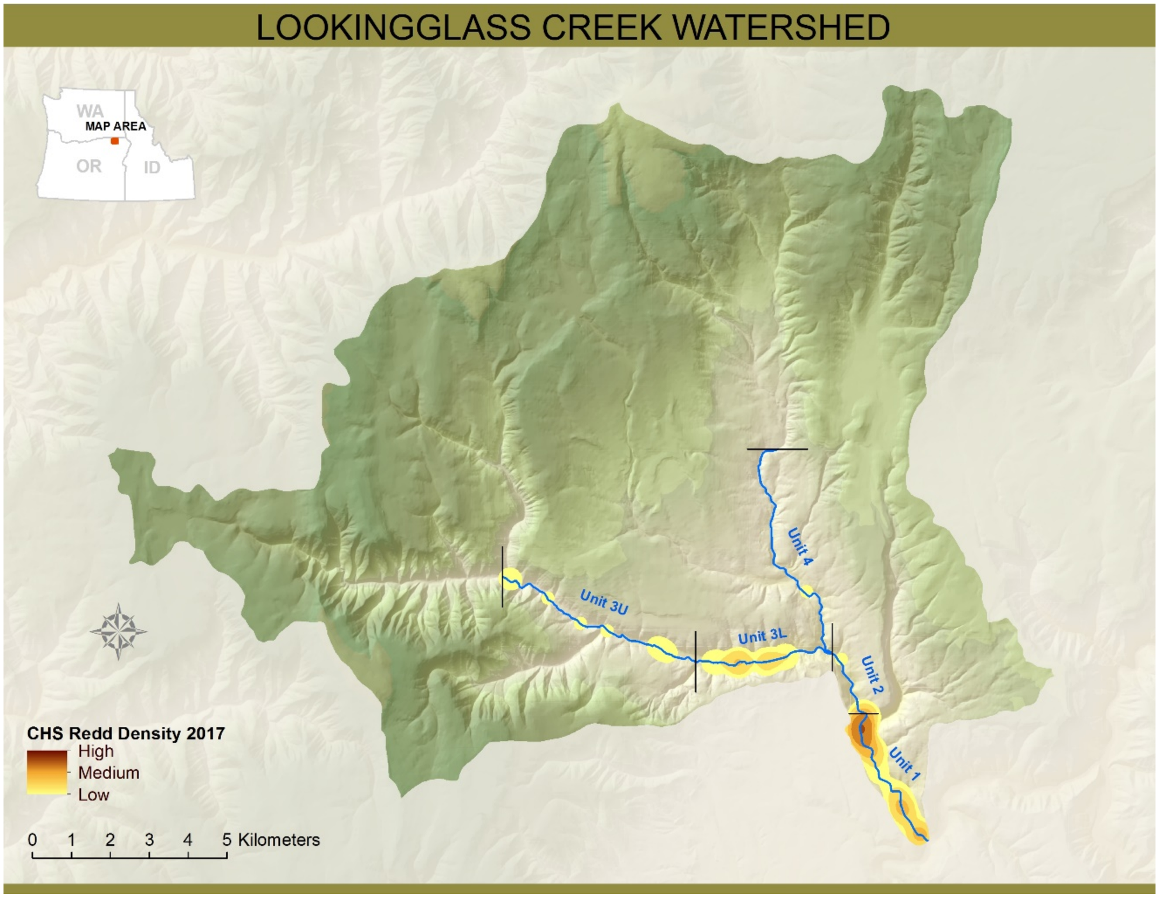

Figure 10. Density map of spring Chinook spawning distribution in Lookingglass Creek by unit, RY 2017.

Since reintroduction efforts began in 2004, Unit 1 has had more redds than any other section in 9 out of 14 years (Table 3). Of note is that 8 of these 9 years have been consecutive, beginning in 2010. Since 2010, as numbers above the weir have increased, we have observed increased numbers of redds located in Unit 2 and 4. Presumably fish are moving into these underutilized areas as suitable spawning habitat becomes more limited. In 2017, there were so few fish upstream of the LH weir, the Chinook had the ability to be selective and most redds were observed in Unit 3L.

Table 3. Numbers of spring Chinook salmon redds by unit, RY 2004-2017. Unit 1 is below the weir, all others are above.

RY	Unit 1	Unit 2	Unit 3L	Unit 3U	Unit 4	Total
2004	49	7	11	20	11	98
2005	10	4	5	20	0	39
2006	28	5	10	12	1	56
2007	22	2	7	23	0	54
2008	39	10	19	56	19	143
2009	30	2	23	40	2	97
2010	89	24	63	62	21	259
2011	129	15	71	105	21	341
2012	133	31	100	136	47	447
2013	47	4	25	30	1	107
2014	105	24	71	82	28	310
2015	91	33	64	67	21	276
2016	144	24	81	83	19	351
2017	68	5	19	7	1	100
Mean	70	14	41	53	14	191
SE	11.1	2.8	8.1	9.6	3.5	33.4

We looked at redds per km by unit between 2009 to 2017 (Table 4) since 2009 was the first complete brood year since reintroduction efforts began. The early years of the reintroduction would not be representative of actual redds per km since the numbers released above the weir in several years were capped at 25 or 50 pair, or fish were hauled from Catherine Creek and released upstream due to very low returns to LGC. Additionally, prior to 2009 fish were released upstream of the confluence of LLGC which could have influenced fish use for that section (Unit 4). As previously identified, a large percentage of redds were constructed in the 4 km unit below the weir during the current re-introduction era (68% of all redds were below the weir in 2017). These redds were plotted with those observed during the endemic era study (1964 to 1971) for comparison (Figure 11). The mean percentage of redds below the weir for the current era are more than twice that of the endemic era (Figure 11, t-ratio = -5.15239, p = <0.001).

Table 4. Number of spring Chinook salmon redds per km by unit, RY 2009-2017.

RY	Unit 1	Unit 2	Unit 3L	Unit 3U	Unit 4
2009	8	1	6	7	1
2010	22	12	16	10	4
2011	32	8	18	18	4
2012	33	16	25	23	9
2013	12	2	6	5	1
2014	26	12	18	14	6
2015	23	17	16	11	4
2016	36	12	20	14	4
2017	17	3	5	1	.2
rkm	4.0	2.0	4.0	6.0	6.0

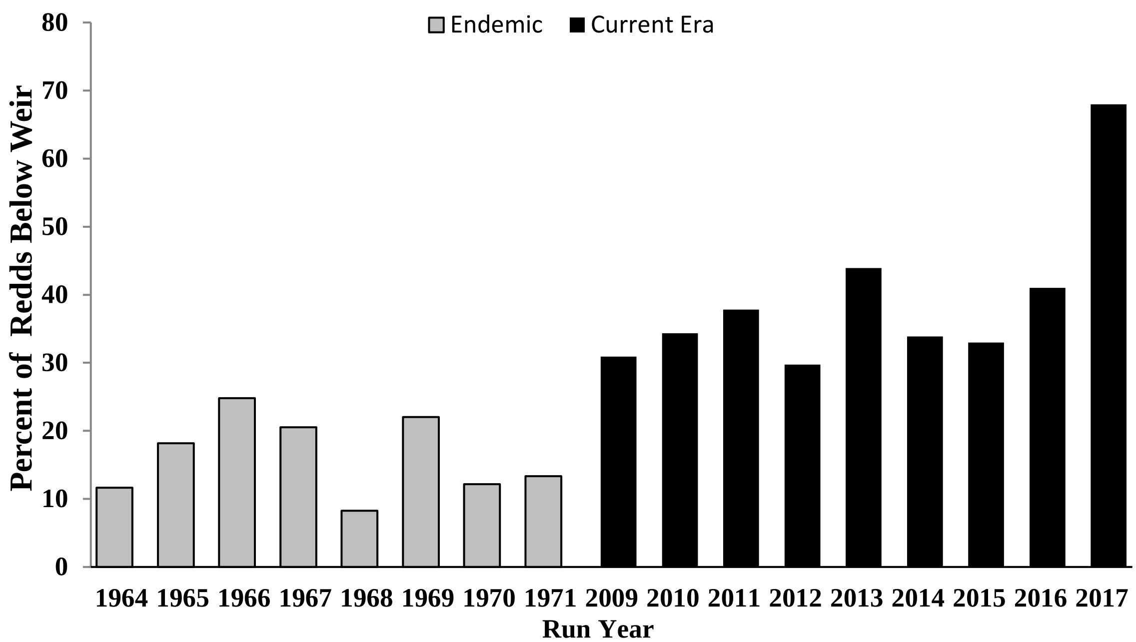

Figure 11. Percentage of total Chinook salmon redds observed below the weir during the endemic era (RY 1964-1971) and the current reintroduction era (RY 2009-2017).

A Wilcoxon Rank Sum test with all pairwise comparisons was used to test if there was a statistical difference in percentage of redds observed between each of the spawning units for pooled data RY 2009-2017 (Table 5). The test showed that Unit 2 and Unit 4 were the only pairwise comparisons that were statistically not significantly different from each other, (Z score=0.30922, p=0.75716), whereas all other pairwise comparisons were significantly different (Table 5), with Unit 1 having the largest percentage of redds over this 9 year period (mean = 37.1% +- 18) followed by Unit 3U (mean = 26.2% +- 9.4), then Unit 3L (mean = 22.5% +- 9.4). Data used to run this analysis are in Appendices 2.2 of this report in Table17.

Table 5. Results of Wilcoxon Rank Sum test used to test for differences between each unit of spawning, RY 2009-2017.

Unit	Unit	Z score	p-value
Unit 1	Unit 4	3.53209	0.00041
Unit 3L	Unit 4	3.53209	0.00041
Unit 3U	Unit 4	3.17888	0.00148
Unit 3U	Unit 3L	2.38416	0.01712
Unit 2	Unit 4	0.30922	0.75716
Unit 3U	Unit 1	-2.73737	0.00619
Unit 2	Unit 3U	-3.26718	0.00108
Unit 3L	Unit 1	-3.53209	0.00041
Unit 2	Unit 1	-3.53209	0.00041
Unit 2	Unit 3L	-3.53209	0.00041

Carcass Recoveries

Carcasses recovered above the LH weir from 24 July through 8 September totaled 8, with 4 identified as female and 4 as male. All of these recovered carcasses were adults and 7 had an opercle punch indicating they had been sampled at the LH weir and one was "unknown" since the operculum was missing and was unable to be determined. Based on these numbers, the weir appeared to be 100% effective at blocking upstream passage. Of these 8 carcass recoveries above the weir, 6 were HOR and 2 were NOR. Carcass recovery efficiency for fish released above the LH weir was 10%, much lower than in most years. As increased amounts of Chinook have been released above the LH weir, there has also been a marked increase in scavengers and predators. Carcasses are rapidly consumed before they can be recovered. This is evident in Unit 3U, the most remote section of LGC. While most of LGC redds are typically constructed in this section, there are frequently fewer carcasses found here than any other unit. With 2017 having so few total returns and thus fish released upstream, carcasses were likely in high demand from predators which may have resulted in the low carcass recovery.

Carcasses recovered below the LH weir from 31 August through 19 September totaled 75. Of these 75 carcasses sampled, there were 58 HOR, as well as 15 Unclipped, and 2 of unknown origin due to being too decomposed to identify. These 15 unclipped fish are either NOR returns or HOR unclipped strays from the Upper Grande Ronde. There were 6 recoveries that had a 1ROP indicating they had been sampled at the weir, passed upstream, and then dropped back or were "flushed" below the weir after being trapped between the pickets and the concrete wall. The decision to flush these fish downstream knowingly makes population estimates and spawner estimates harder to calculate, however the preference is to allow them to spawn below rather than perish in this small area.

Population Estimate Above the Weir

The total number of Chinook passed above the weir was 90, then that number was decreased by the 6 “punched” adults that were recovered below the weir. The Chapman modification of the Peterson method was then applied using marked/unmarked recoveries. The population estimate of jacks was 15, and the adult estimate was 69 (Table 6). Fish per redd estimates were 2.16 for adults, with an average of 2.26 since reintroduction began.

Table 6. Population estimates, mean, and standard error of the mean (SEM), redds, and fish/redd of naturally spawning spring Chinook salmon above the LH weir, RY 2004-2017.

	Population Estimate			Fish/Redd	
RY	Adults (SEM)	All Ages (SEM)	Redds	Adults/redd	All/redd
2004	99 (11.9)	99 (11.9)	49	2.02	2.02
2005	40 (4.9)	46 (5.6)	29	1.38	1.59
2006	47 (10.8)	53 (12.1)	28	1.69	1.91
2007	65 (11.9)	71 (13.2)	32	2.03	2.22
2008	179 (18.1)	188 (18.8)	104	1.72	1.81
2009	83 (19.7)	151(34.7)	67	1.24	2.26
2010	344 (20.4)	372 (21.1)	170	2.02	2.19
2011	439 (26.4)	507 (29.1)	212	2.07	2.39
2012	941 (56.2)	941 (56.0)	314	3.00	3.00
2013	160 (20.0)	228 (27.6)	60	2.67	3.83
2014	611 (44.8)	646 (46.4)	205	2.98	3.15
2015	724 (114.3)	758 (120.0)	185	3.91	4.10
2016	569 (40.6)	574 (41.0)	207	2.75	2.77
2017	69 (23.3)	84 (28.6)	32	2.16	2.63
Means	312	337	121	2.26	2.56

Spawner Estimate Above the Weir

Chinook were released right near the hatchery intake in the deep pool just upstream of the pickets. We observed low pre spawn mortality, however few carcasses were observed in general due to the low numbers released above the weir (Table 7). Prespawning mortality has varied from zero to a high of 54.2% during the current reintroduction era. In 2017, the mean percent of pre spawn mortality for 2004-2016 was used since only four female carcasses were recovered above the weir (Joseph Feldhaus ODFW, personal communication). Spawner estimates above the weir (adults only) have ranged from 37-742, with a mean of 233 over the reintroduction period.

Table 7. Population Estimates, Prespawn Mortality (PSM), and Spawner Estimate for spring Chinook salmon above the LH weir, RY 2004-2017.

	Population Estimate			Spawner Estimate	
RY	Adults	All Ages	PSM	Adults	All Ages
2004	99	99	0.000	99	99
2005	40	46	0.083	37	42
2006	47	53	0.000	47	53
2007	65	71	0.083	60	65
2008	179	188	0.000	179	188
2009	83	151	0.125	73	132
2010	344	372	0.085	315	340
2011	439	507	0.136	379	438
2012	941	941	0.212	742	742
2013	160	228	0.263	118	168
2014	611	646	0.299	428	453
2015	724	758	0.542	332	347
2016	569	574	0.305	395	399
2017	69	84	0.164*	58	70
Means	312	337	0.164	233	253

Spawner estimate is population estimate above the weir multiplied by pre spawn mortality of females above the weir.
**In 2017, due to only retrieving four female carcasses above the weir, a valid PSM percent could not be determined. Therefore an average from 2004-2016 was used, (Joseph Feldhaus ODFW, personal communication)*

1.5.1.1 Life History

Length at Known Age

Scales were collected on a portion of returning NOR fish at the LH weir or on spawning surveys which were used to determine age (n=33). Snouts were collected on spawning surveys from HOR carcasses with a CWT present and this tag was used for determining age (n=26). These known ages are represented in the table below (Table 8). Snouts were collected from only 1 carcass above the LH weir and 25 below. All snouts were scanned to verify the presence of a wire prior to submittal to the ODFW Clackamas lab. If the snout did not have a wire, it was discarded. A total of 26 snouts with a wire were ultimately submitted to the Clackamas lab for retrieval of the CWT, and data for 25 snouts was processed and returned to CTUIR. Of the 25 snouts processed, 13 were LGC releases, 2 were from CC, and 10 were from UGR. Therefore, nearly half of all recoveries with a CWT present were strays (48%). These fish likely successfully spawned below the LH weir, as 12 of the carcasses recovered were females and completely spawned out.

There were many more NOR jacks that were aged when compared to HOR jacks, and one age 3 NOR female (Table 8). The age 3 NOR males were an average of 13 mm larger than the HOR, however the age 4 HOR fish are larger than NOR for both sexes. Also, both age 4 NOR and HOR males were considerably larger than females. There were small sample sizes for age 5 fish for both NOR and HOR, therefore meaningful comparisons are difficult. However, all of the age 5 returns were similar in size. In general, there are small sample sizes for known age 3 and age 5 fish for both NOR and HOR. There were 3 HOR fork lengths that were not used in this comparison below due to the high likelihood that data was incorrectly documented at some point of the process of collection and submittal. This included a 220mm age 3, a 290mm age 4 and a 940mm age 4. There was also 1 HOR fish excluded due to the fact that no fork length was recorded.

Table 8. Mean FL (mm) at known age by sex and origin of LGC spring Chinook, RY 2017.

Origin	Sex	Age	$\bar{X}$ FL	Range	SE	N
NOR	M	3	522	396-615	17	15
NOR	F	3	618	618		1
NOR	Combined	3	528	396-618	17	16
NOR	M	4	727	665-824	26	5
NOR	F	4	703	605-790	27	6
NOR	Combined	4	714	605-824	18	11
NOR	M	5	896	825-963	40	3
NOR	F	5	895	860-950	28	3
NOR	Combined	5	896	825-963	22	6
HOR	M	3	509	480-560	18	4
HOR	M	4	811	740-855	18	6
HOR	F	4	734	690-785	10	10
HOR	Combined	4	763	690-855	13	16
HOR	F	5	860	860		1

**3 fish with a CWT were thrown out due to erroneous data, and 1 HOR fish no fork length recorded*

Female Fork Lengths:

Using data from 2007 to 2017, we calculated means and 95% confidence intervals of female fork lengths of NOR and HOR returns to the adult weirs for CC and LGC stocks (Table 9). Data was removed from the analysis that pre-dated 2007, as these data could have Rapid River stock influences that could upwardly skew LGC mean fork lengths. Moreover, 2007 was the first naturally spawned returns to LGC (jacks). We also plotted frequency distributions of female fork length for both NOR and HOR LGC stock (Figure 12, Figure 13). Mean fork length of all ages combined for the LGC 2017 return year was 752.1 mm for NOR, which was above the 11-year mean of 743.4 (Table 8). For HOR, the 2017 mean was 745.3 mm compared to an 11-year mean of 716.7. In general, the NOR female returns have been larger than HOR female returns for both CC and LGC, (Table 8).

Table 9. Mean FL (mm) and 95% confidence intervals for known age females by stock and origin, RY 2007-2017.

Stock	Origin	Mean FL(mm)	SE	Upper 95 %	Lower 95%	N
CC	NAT	727.7 (± 4.5)	2	732.2	723.2	702
LGC	NAT	743.4 (± 12)	6	730.9	720.9	108
CC	HAT	725.9 (± 5)	3	755.4	731.4	312
LGC	HAT	716.7 (± 7)	4	723.7	709.7	163

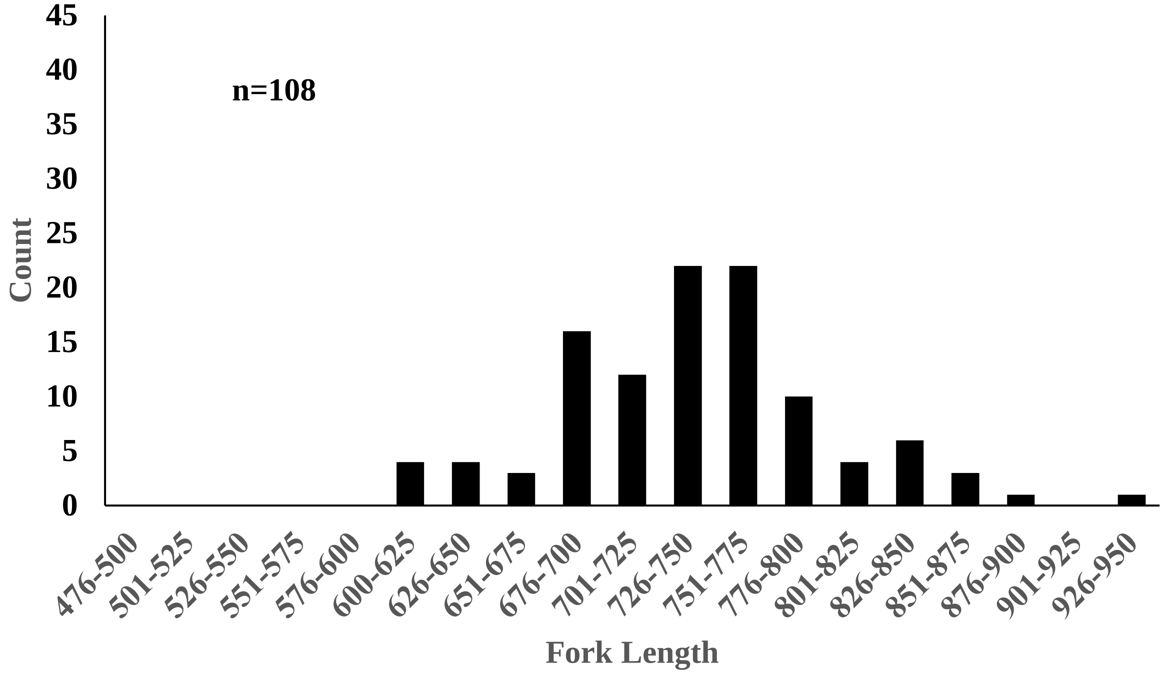

Figure 12. Frequency distribution of NOR FL (mm) of returning adult female spring Chinook salmon for Lookingglass Creek, RY 2007-2017. Data are from known age females.

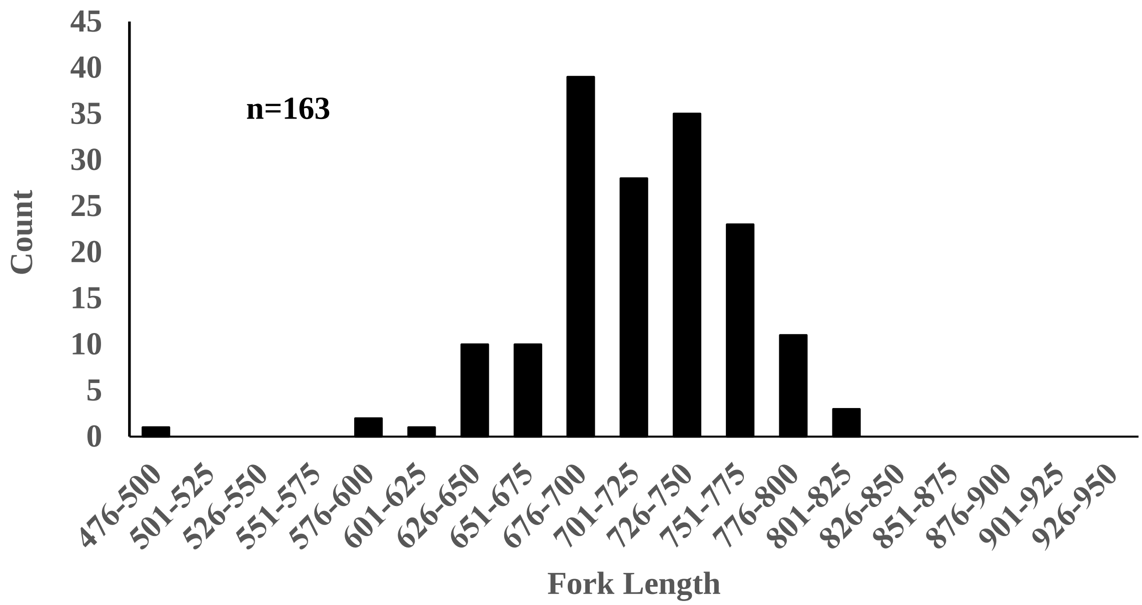

Figure 13. Frequency distribution for HOR FL (mm) for returning adult female spring Chinook salmon to Lookingglass Creek, RY 2007-2017. Data are from known age females and does not include strays.

1.5.1.2 Productivity

Recruits per Spawner (R/S)
BY 2012 recruits per spawner for adults (excluding jacks) was similar to the last few years since BY 2008, at 0.5 (Table 10). Recruits per spawner for BY 2001-2005 CC NOR (adults+jacks) ranged from 0.1-0.7 (Feldhaus, et al., 2012) and increased to 2.2 in BY 2006 and 3.2 in BY 2007 (Feldhaus, et al., 2011). Recruits per spawner (adults) were also higher for LGC NOR in 2006 and 2007 at 2.9 and 2.3, respectively. It is not clear what factor may have led to the higher Recruits per Spawner in those years in both streams. Recruits per spawner has been below the replacement value of 1.0 for 6 out of the last 9 completed brood years. In the latest status review update, spring Chinook populations in CC and UGR remained at high risk for both abundance and productivity, even though short-term natural spawner abundance had increased in CC (NOAA, 2011).

Table 10. Completed BY NOR returns, spawners by BY, and Recruits per spawner for LGC NOR spring Chinook salmon, BY 2004-2012.

	BY NOR returns[a]		Spawners[b]		R/S	
BY	Adults	All	Adults	All	Adults[c]	All[d]
2004	55	62	99	99	0.6	0.6
2005	78	82	37	42	2.1	1.9
2006	138	162	47	53	2.9	3.1
2007	135	152	60	65	2.3	2.3
2008	141	171	179	188	0.8	0.9
2009	61	64	73	132	0.9	0.5
2010	185	245	315	340	0.6	0.7
2011	254	289	379	438	0.7	0.7
2012	335	370	742	742	0.5	0.5
Means	154	177	215	233	1.3	1.2

[a] *Complete NOR BY returns from BY X for Adults and All ages*
[b] *Total Adult and All Spawners for BY X*
[c] *(NOR BY X returns at ages 4 and 5)/BY X Adult spawners;*
[d] *(NOR BY X returns at ages 3, 4 and 5)/BY X All spawners*

1.5.2 Juvenile Spring Chinook Salmon

1.5.2.1 Abundance

Outmigrants

The rotary screw trap was fished 59% of the possible days during January-June 2017, which is far lower than in most years. This was due to the exceptional winter snow pack followed by record setting precipitation levels in the spring. High flows and heavy debris made trapping difficult and unsafe for juvenile salmonids and staff. When the screw trap was fished, it was only able to be fished on the outside edge of the thalweg. Flows did not recede until mid-June. This event led us to adjust the calculation of the spring outmigrant estimate which is detailed below under *Outmigration Estimate*. During July-December 2017, the rotary trap was fished 72% of the time. This number is also lower than most preceding years. There was a mortality event on August 18 which killed 241 NOR BY16 Chinook. This event required us to pull the trap immediately and notify NMFS. We were unable to fish during the review of this event, between 21 August and 6 September. The trap was pulled again between 10 September and 16 September 2017, due to LH road construction and an inability to access the screw trap. These are both typically periods of increased juvenile emigration.

Beginning in January, fry begin to be captured in the screw trap. Obtaining an accurate estimate of January-June (fry) outmigrants is difficult because of high flow and debris during the spring and the small size of fish which limits the marking options available. The fry captured during these times are counted and passed below the trap. Numbers totaled 1 and 17 for January and February respectively, but increased from March to June, totaling 493 fry. The largest catches of fry occurred in April (n=311). There were no attempts at estimating these fry and they were not included in the outmigrant estimate for BY 2015 as they appeared to not be emigrating, but instead were getting flushed into the trap during high flows. Fish are tagged that have a fork length over 60 mm beginning 1 July of the migration year through the following 30 June of the next year. BY 2015 first-time captures in the screw trap from 1 July 2016-30 June 2017 totaled 8,240 with less than 1% mortality (n=36).

Outmigrant Estimate
The BY 2015 outmigrant estimate was derived using Darr 2.9.1 and was estimated for the period of July 1 2015 through 31 December only (Table 11). There was no attempt to estimate the spring outmigrants since the trap was fished an insufficient amount to get a statistically viable estimate. This was due to extremely high flows that persisted until late June. Therefore, few fish were tagged and recaptured between the spring migration between 1 January and 30 June. Instead, the mean percentage of spring outmigrants captured between 2004-2016 (15%) was applied to the fall outmigrant estimate and extrapolated from that (Table 11). This is the fourth largest outmigrant estimate since reintroduction efforts began. This correlates well with also having the fourth largest number of observed redds above the weir for BY 2015. The mean outmigrants per redd for the current reintroduction era is 219.

Table 11. LGC NOR spring Chinook salmon outmigrant summary, BY 2004-2015.

BY	MY	Outmigrants	SE	Redds AW[a]	Outmigrants/Redd
2004	2006	9,404	1,278	49	192
2005	2007	14,091	1,980	29	486
2006	2008	12,208	3,866	28	436
2007	2009	7,847	1,174	32	245
2008	2010	30,289	2,266	104	291
2009	2011	12,279	759	67	183
2010	2012	13,749	805	170	81
2011	2013	21,517	1,185	212	101
2012	2014	54,759	4,569	314	174
2013	2015	10,191	610	60	170
2014	2016	26,384	1,777	205	129
2015	2017	26,502*	1,758	185	143
Means		19,935	1,836	121	219

[a]*AW=above the LH weir* ** Spring outmigrant estimate calculations explained in text above*

Outmigration timing

Fish numbers leaving LGC during July and August are typically low as flows decrease and water temperatures increase. Low flows make screw trapping difficult, as the cone may turn very slowly, or become "hung up" on rocks in the shallow water. Outmigrants by season estimated from the screw trap catch were 49% for fall 2016, 37% winter 2016, and 15% spring 2017 (Table 12). In general, the majority of LGC juvenile Chinook migrate between the months of October-December. However, there have been a couple of years where larger percentages left from July-September, to include 2017. Even with some of these shifts between fall and winter months, the vast majority of LGC stock leave as pre-smolts in the fall/winter. The mean from BY 2004-2014 indicates that number to be 85%, with only 15% of outmigrants leaving in the spring (Table 12). This observed pattern was similar to that reported for the previous Rapid River reintroduction era (McLean, et al., 2001) and (Burck, 1993). However for both reintroduction eras, higher percentages left during the winter months while Burck observed more outmigrants leaving in the fall. We are not clear why there is a slight shift in outmigration timing. A similar pattern of most outmigrants leaving as presmolts during fall/winter occurs for CC outmigrants, our donor stock (Anderson, et al., 2011).

Table 12. Summary of seasonal outmigration of LGC NOR spring Chinook salmon, BY 2004-2015.

BY	MY	Jul-Sept %	Oct-Dec %	Jan-Jun %
2004	2006	43	47	10
2005	2007	33	64	2
2006	2008	36	44	20
2007	2009	16	64	21
2008	2010	21	55	24
2009	2011	9	69	22
2010	2012	34	49	17
2011	2013	26	55	20
2012	2014	73	24	4
2013	2015	30	60	10
2014	2016	37	53	10
2015	2017	49	37	15*
	Means	33	52	15

MY totals may not sum to 100 due to rounding

**For Spring of 2017, the trap was not fished often enough to calculate a valid population estimate due to record high snow fall followed by rain. . The mean of 15% spring outmigrants from 2004-2016 was applied to the fall estimate (assumed to be 85%).*

Size of tagged outmigrants in the screw trap by season

Sample sizes by season for PIT-tagged outmigrating juvenile Chinook were 587, 228, and 115 for fall, winter and spring respectively. Mean FL by season of these tagged fish were 69, 81, and 83 mm for fall, winter and spring groups. The small amount of growth from winter to spring could be in part due to low flows, cold temperatures, and high densities of juveniles. Mean weights increased from 4.3-6.3g from fall 2016 to spring 2017. Mean K was 1.21, 1.18, and 1.11 for the fall, winter, and spring groups, respectively. As expected, fish increased in size from fall to spring (Figure 14), however, fish had a slightly lower K factor in the spring. In general, K factor is highest in the spring, when conditions are more favorable. This deviation from the norm could be due to the low sample size collected in the spring.

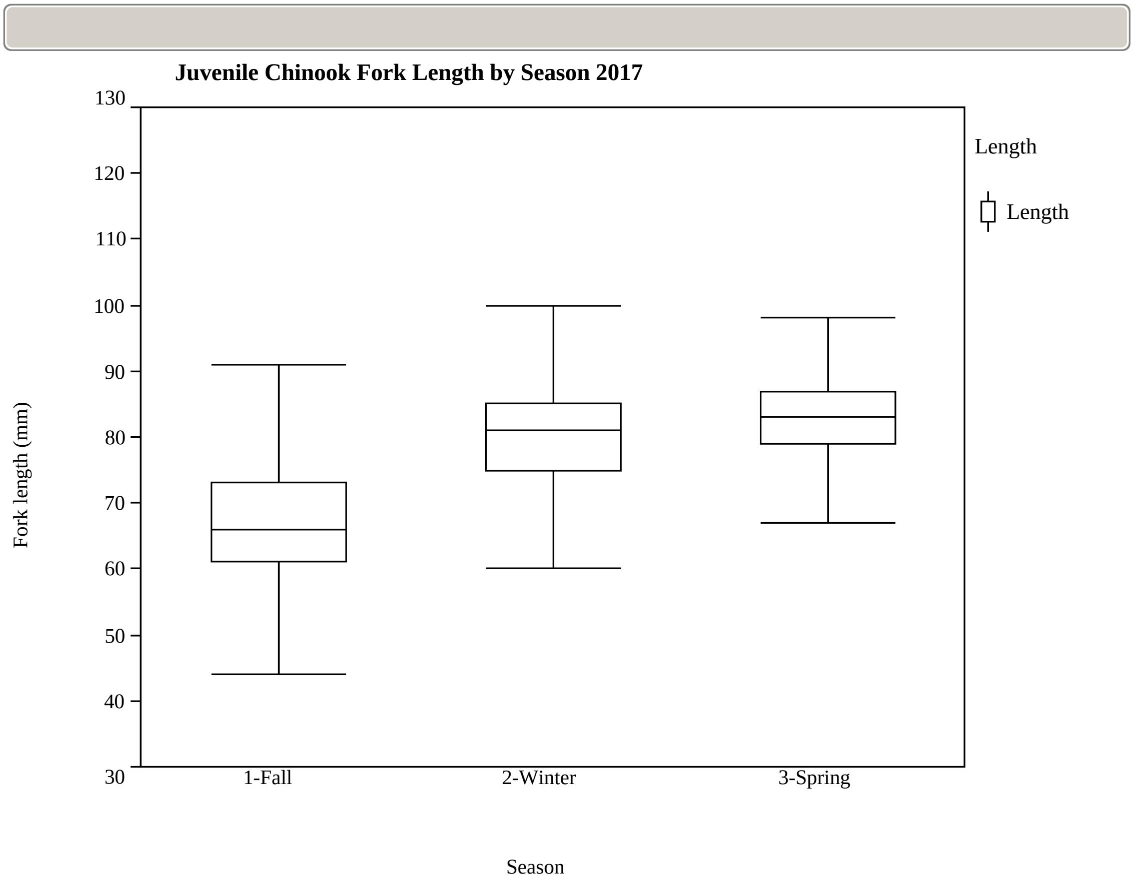

Figure 14. Box plots of FL (mm) by seasonal group for NOR spring Chinook salmon outmigrants tagged or measured in the Lookingglass Creek screw trap, BY 2015. Error bars indicate minimum and maximum sizes observed by season.

Outmigrants/redd plotted against redds above the LH weir seem to indicate that there is potentially a carrying capacity level that has been reached. Based on the figure below (Figure 15) showing that in general, there are higher outmigrants per redd when there are fewer redds above the weir. The BY 2012 outmigrant total was the highest observed during the current reintroduction era, which correlated well with the largest amount of redds above the weir; however the outmigrant estimate was not as high as expected. This could indicate spawner saturation, though observing this pattern is not necessarily proof of a negative pattern, (Peter Galbreath, CRITFC personal communication). This will be looked at more in depth with multiple metrics and be discussed with managers and co-managers in the future.

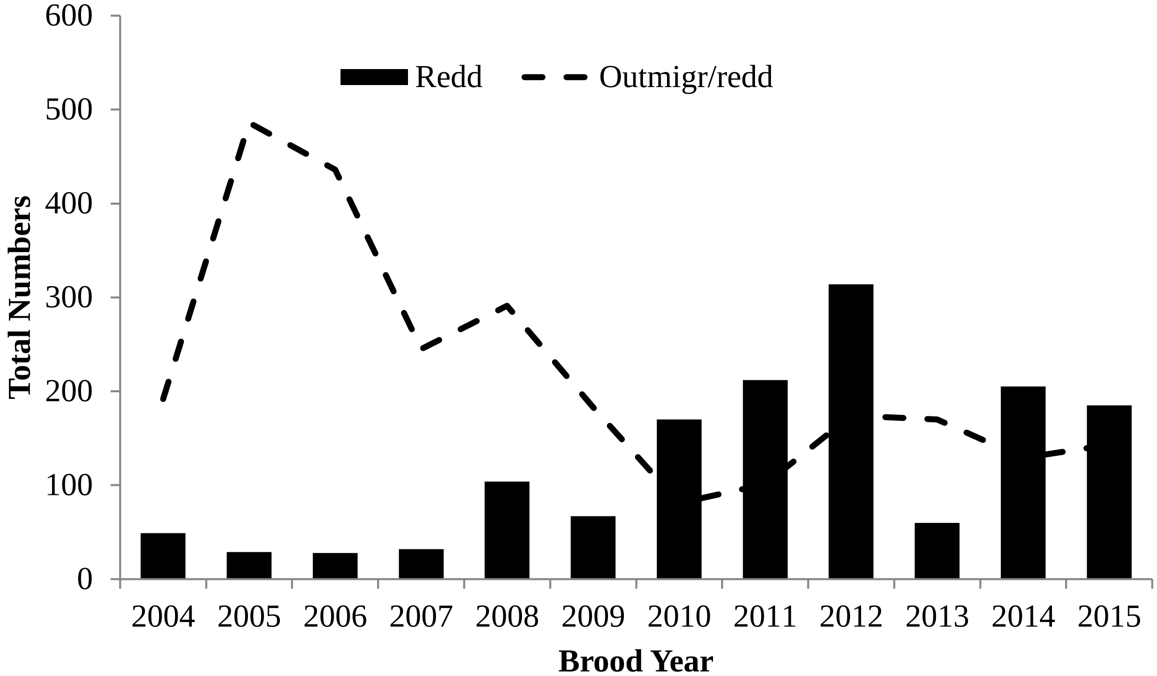

Figure 15. Outmigrants/redd and redds above the weir for BY 2004-2015.

1.5.2.2 Life History

Survival Estimates

Survival probabilities (SE) to Lower Granite Dam (LGD) were 0.153 (0.019), 0.146 (0.019), 0.162 (0.032), and 0.515 (0.094) respectively for the summer, fall, winter, and spring groups of BY 2015. Spring survival is substantially higher than the summer, fall and winter groups on a consistent basis (Figure 16). This could be in part due to the much shorter travel time to LGD for the spring group, and is typically a time of year when flows are favorable (Figure 18). The juveniles that are leaving in the fall and winter are overwintering somewhere within the Grande Ronde Subbasin where conditions may be much less complimentary. We are also observing increased numbers of redds above the weir, which may have led to a slight decrease in survival for all seasonal groups (Figure 17).

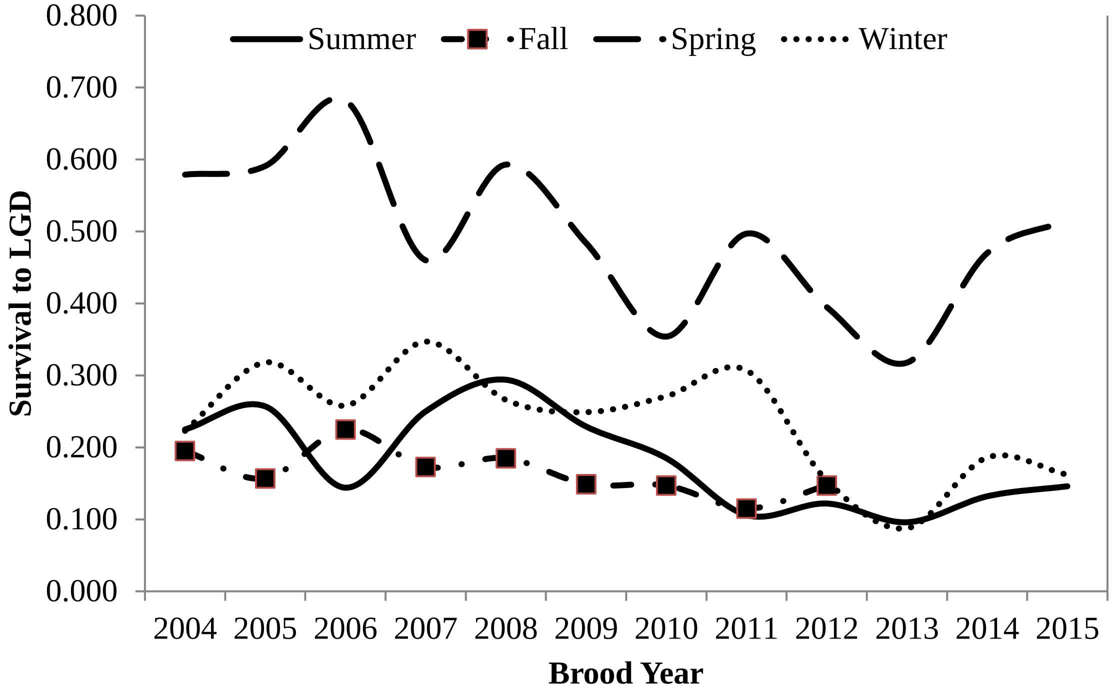

Figure 16. Survival probabilities of NOR spring Chinook salmon for summer, fall, winter, and spring groups, BY 2004-2015.

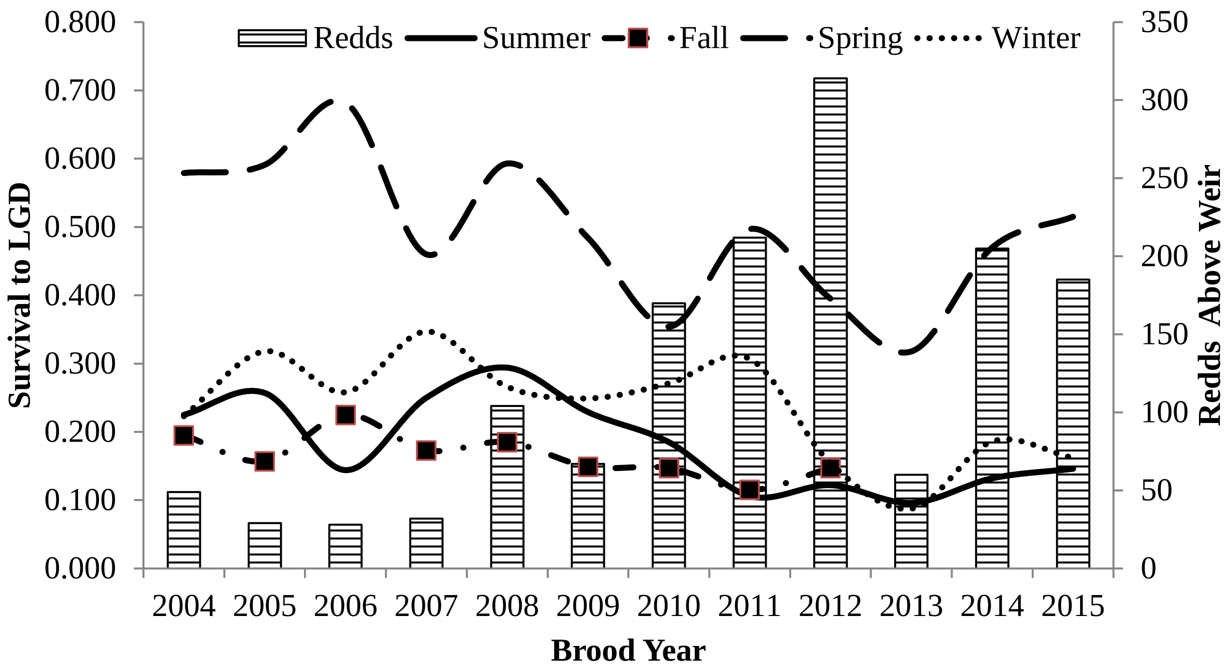

Figure 17.Survival probabilities of NOR spring Chinook salmon for summer, fall, winter, and spring groups, BY2004-2015, with redds on the z axis.

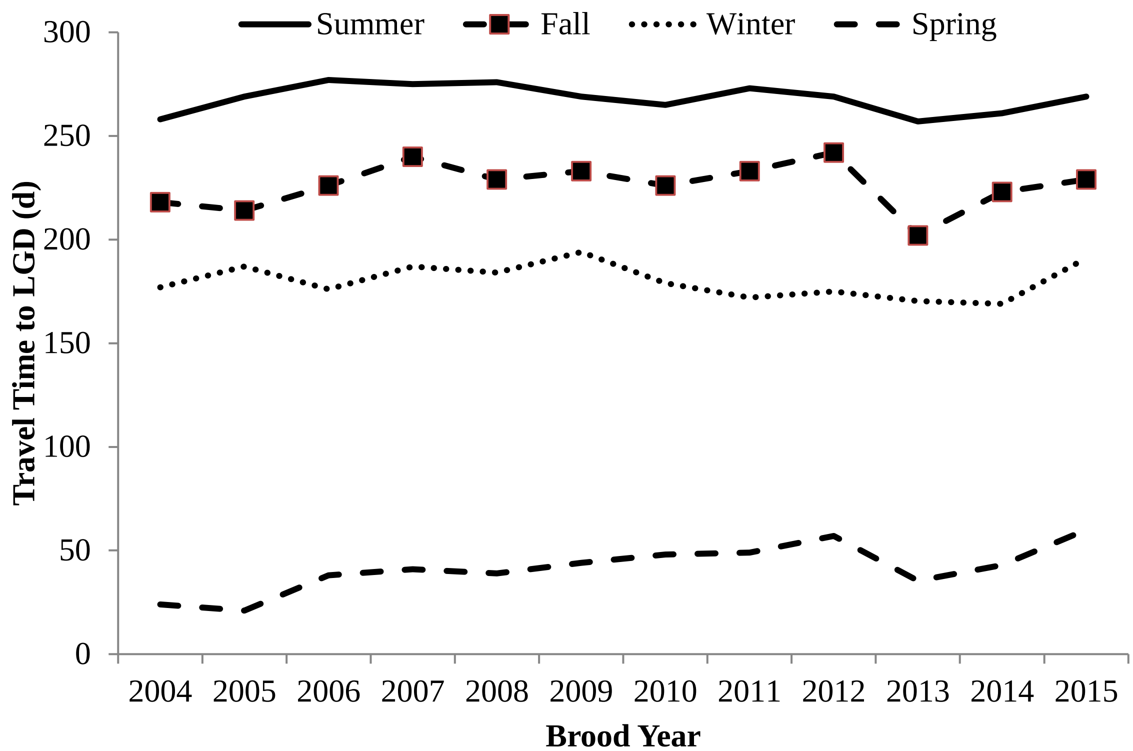

Figure 18. Harmonic mean travel time (d) to LGD for Lookingglass Creek NOR summer parr, and fall, winter, spring outmigrants, BY 2004-2015.

During the current reintroduction era, we have observed more fish typically leave during the winter months (Oct-Dec) than the fall months (July-Sept). Juveniles emigrating in the winter have a higher mean survival rate to LGD compared to the fall, so this shifted migration pattern could prove complimentary (Figure 19). Mean survival for fall, winter and spring is 18%, 24%, and 49%, respectively. Conversely, the mean percent of juveniles emigrating during the fall, winter, and spring is 33%, 52%, and 15%, respectively. Therefore, while spring survival is the highest at 49%, only 15% of all LGC juveniles are emigrating during that time, (Figure 19).

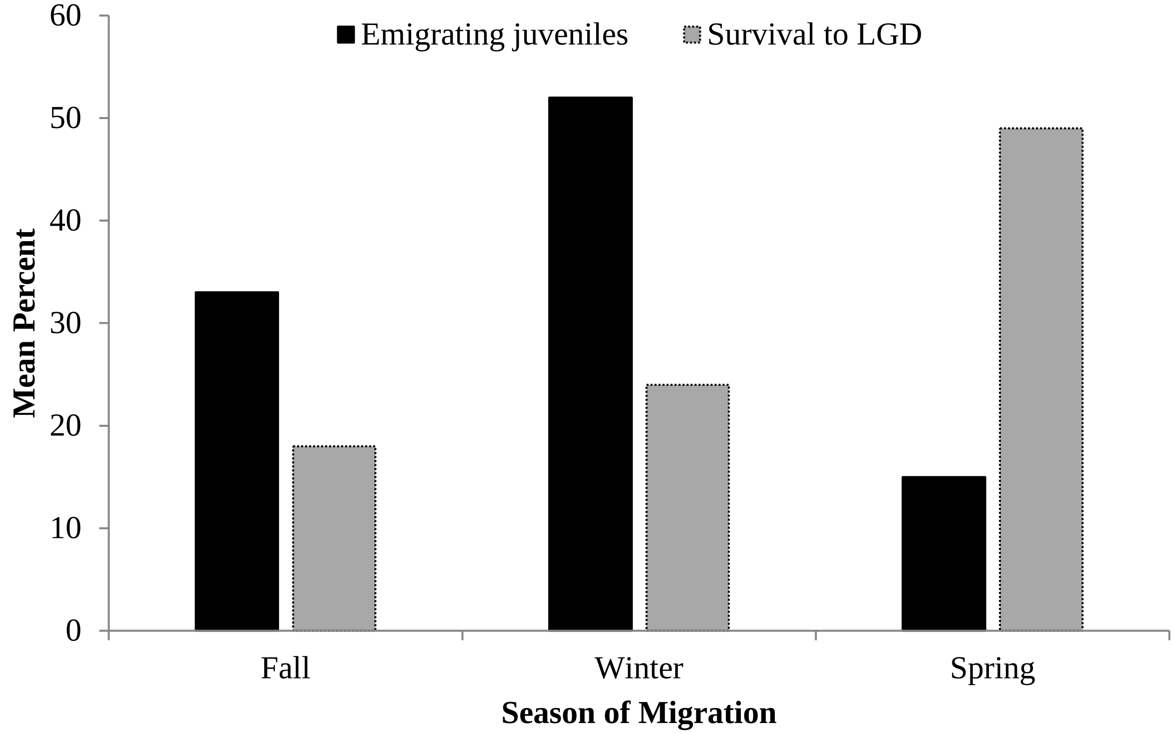

Figure 19. Plot of mean percent of fish emigrating and the corresponding survival by season, BY 2004-2015.

In the earlier years of the LGC reintroduction, the returns and/or outplants available were small and therefore small numbers were released above the weir to spawn. The mean number of tabulated redds for BY 2004-2009 was 52, compared to 191 between BY 2010-2015. When looking at juvenile mean size and survival variances during low redd years vs high redd years, we observed a marked increase in the mean FL of the outmigrants and the survival to LGD for all seasonal groups when the number of redds above the weir was lower (Table 13). This observed difference could be due to less competition for habitat and nutrients in low redd years.

Table 13. Summary of BY 2004-2009 and BY 2010-2015 mean FL and survival during low redd years vs high redd years.

Brood Year	Season	Mean Redds	Mean FL	Mean Survival
2004-2009	Summer	52	72	0.18
2010-2015		191	69	0.14
2004-2009	Fall	52	80	0.23
2010-2015		191	72	0.13
2004-2009	Winter	52	89	0.28
2010-2015		191	83	0.19
2004-2009	Spring	52	97	0.56
2010-2015		191	88	0.42

Smolt Equivalent Estimate

Smolt equivalent (S_{eq}) estimates (estimated outmigrants for each group surviving to LGD) for fall 2016, winter 2016, and spring 2017 were 1,879, 1,577, and 2,008, respectively. This equated to a BY 2015 total of 5,464. BY 2015 S_{eq} was above the mean for the current era, however S_{eq}/spawner was well below the mean (Table 14). S_{eq} /spawner since 2010 has ranged between 11 and 24. Why S_{eq} /spawner was consistently higher prior to 2010 is unclear.

Smolt to Adult Return

BY 2012 NOR SARs were above the BY 2004-2012 means. The BY 2004-2012 adult only mean of 3.3% is at the low end of the 2-6% range and below the 4% average recovery objectives for Snake River Chinook and steelhead (NWPCC , 2014).

Table 14. S_{eq} to LGD and SAR for LGC NOR spring Chinook salmon, BY 2004-2015.

	NOR BY returns				SAR (%)	
BY	All	Adult	S_{eq}	S_{eq}/spawner[a]	All[b]	Adults[c]
2004	62	55	2,446	24	2.5	2.2
2005	82	78	4,280	116	1.9	1.8
2006	162	138	3,669	78	4.4	3.8
2007	152	135	2,784	46	5.5	4.8
2008	171	141	10,620	59	1.6	1.3
2009	64	61	3,671	50	1.7	1.7
2010	245	185	3,319	11	7.4	5.6
2011	289	254	5,925	16	4.9	4.3
2012	370	335	7,596	24	4.9	4.4
2013			1,153			
2014			5,151			
2015			5,464			
Mean	177	153	4,673	47	3.9	3.3

[a] S_{eq}*/Adult spawners from Table 9*

[b] *(NOR BY X returns All ages)/*S_{eq} *BY X*

[c] *(NOR BY X returns at ages 4 and 5)/*S_{eq} *BY X*

**Caveat for 2015, Smolt equivalent low due to spill and low detects at LGD caused by uncharacteristically low flows that MY.*

Monthly sampling

The section of LGC known as 3L (formerly Nielson's property) has been purchased by the CTUIR and has restoration work planned to restore the streams connection with the floodplain. This work is slated for implementation in the near future, possibly as early as 2019. This section contains the "standard site" that has been sampled consistently during the endemic era, the RR reintroduction era, and currently with the LGC stock (Boe, et al., 2014). The standard site (rkm 8.9) in the future may be used as the "treatment" location and the upstream site at the section break of 3U/ 3L at the footbridge (rkm 10.5) used as the "control" while we evaluate habitat usage before, during, and after in stream work is completed. Each month around the 20th (July, August, September) we attempt to capture 50 fish using snorkel/seine methods at both of these sites. We typically are not able to snorkel for parr in June due to higher spring flows coupled with the small size of the fish and the risks of handling and anesthetizing them. BY 2015 parr sampled totaled 77 in July, 104 in August and 88 in September 2016. Mean FL increased in a generally linear pattern from July-September at both sites, as expected. For BY 2015 parr at the standard site, mean fork length for July, August, and September was 66.2 mm, 81.3 mm, and 83.1 mm, respectively. For BY 2015 parr at the footbridge site (rkm 10.5), mean fork length for July, August, and September was 63.3 mm, 74.8 mm, 78.3 mm, and respectively. Parr sampled at the upstream footbridge site are consistently smaller than at the standard site, likely due to colder water temperatures. At the standard site (rkm 8.9), the average FL for BY 2005-

2015 in July, August, September was 67 mm, 76 mm, and 84 mm, respectively (Figure 20). During the month of September, fish have begun to move lower in the system and we often do not meet our goal of 50 fish at either site.

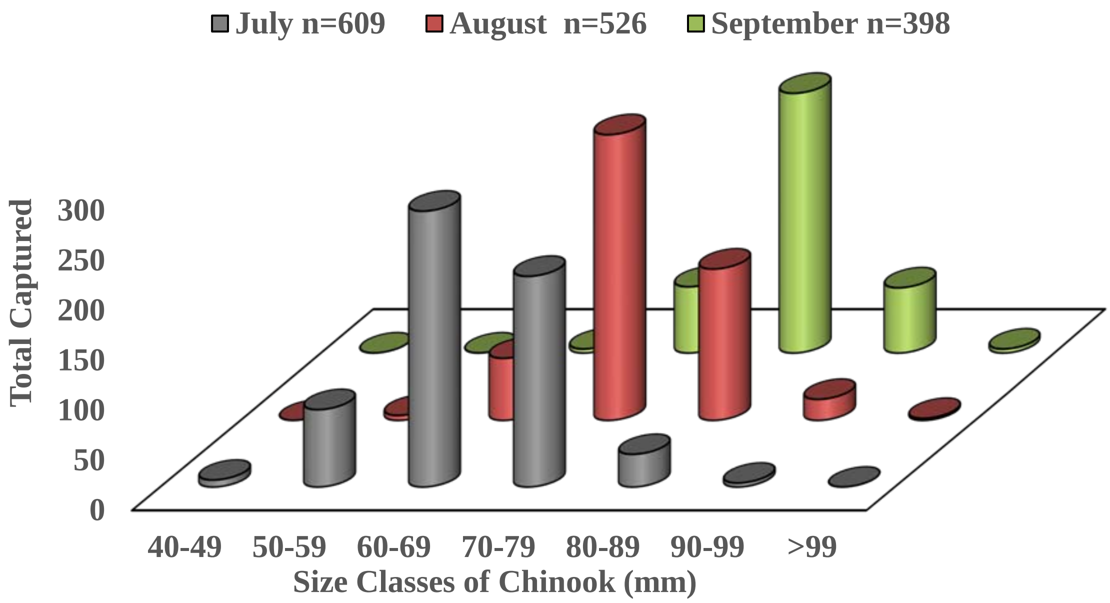

Figure 20. Seasonal growth of juvenile spring Chinook salmon captured during monthly sampling for July, August, September at the standard site (rkm 8.9), BY 2005-2015.

At the footbridge site (rkm 10.5) the average FL for BY 2005-2015 in July, August, September was 63 mm, 73 mm, and 82 mm, respectively. There was much more variability a few kilometers upstream at the footbridge site, with much smaller fish observed in August and September and a much wider area of overlap between months (Figure 21).

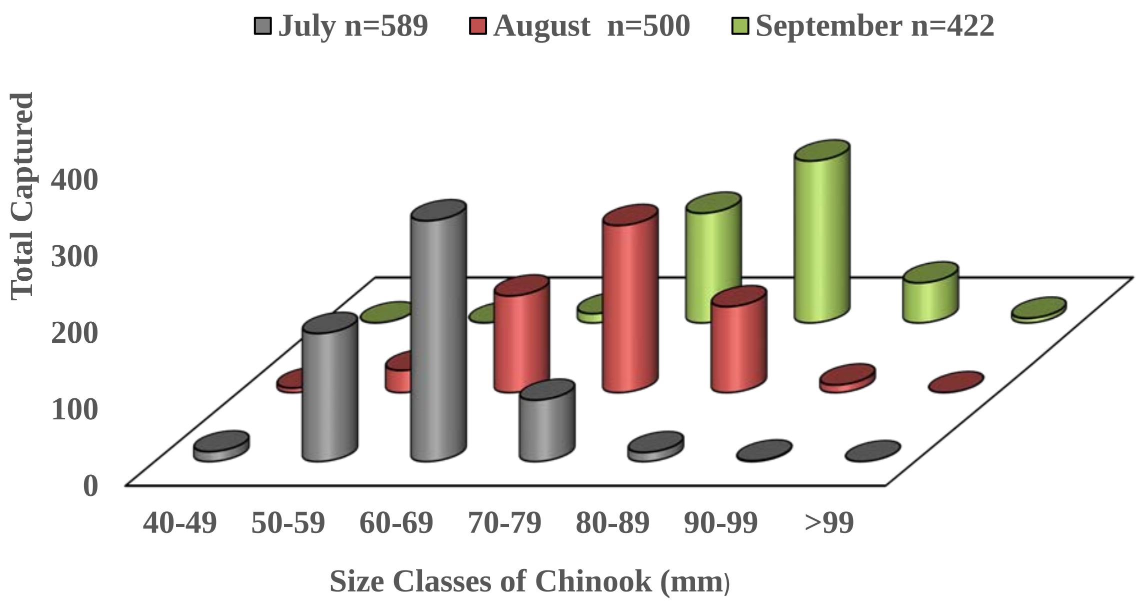

Figure 21. Seasonal growth of juvenile spring Chinook salmon captured during monthly sampling for July, August, September at the footbridge site (rkm 10.5), BY 2005-2015.

Precocials

There was only 1 BY 2015 NOR precocials caught in the screw trap on 10 September 2017 and FL was 96 mm. There were also 2 adipose clipped precocials that must have moved upstream from the LH and then down again looking for potential mates. Each year several are caught in the screw trap. These are scanned for PIT tags, a genetic sample taken, measured, weighed and released downstream of the trap. The low number of precocials captured this season is likely due to the fact that the screw trap was pulled from 21 August to 6 September due to the aforementioned mortality event, and then again from 10 September to 16 September due to LH road construction and a lack of access. This time frame is when adult Chinook are spawning and most precocials are captured in the rotary trap. The numbers of precocials Burck (1993) reported in the bypass trap ranged from 158-575 annually, much higher than the numbers seen during the current reintroduction era. The lower numbers observed are likely a function of the overall lower abundance of outmigrants, however this is an interesting difference in population dynamics.

Summer Parr Sampling

A total of 955 BY 2015 parr where collected using snorkel/seine methods from 1 August to 5 August 2016 (Figure 22). These fish were collected from the upper rearing areas of LGC in the upper portion of section 3L and the lowest section of 3U between rkm 8.9 and 12.0 (Figure 23). The CTUIR tagged these fish and returned them to the stream reach from which they were collected. Fork lengths were taken from 356 of these at the time of tagging (Figure 24). The vast majority of the tagged fish were between 60-79 mm (85%).

Figure 22. Snorkel/seining of juvenile spring Chinook for the summer parr group collected in unit 3U and 3L.

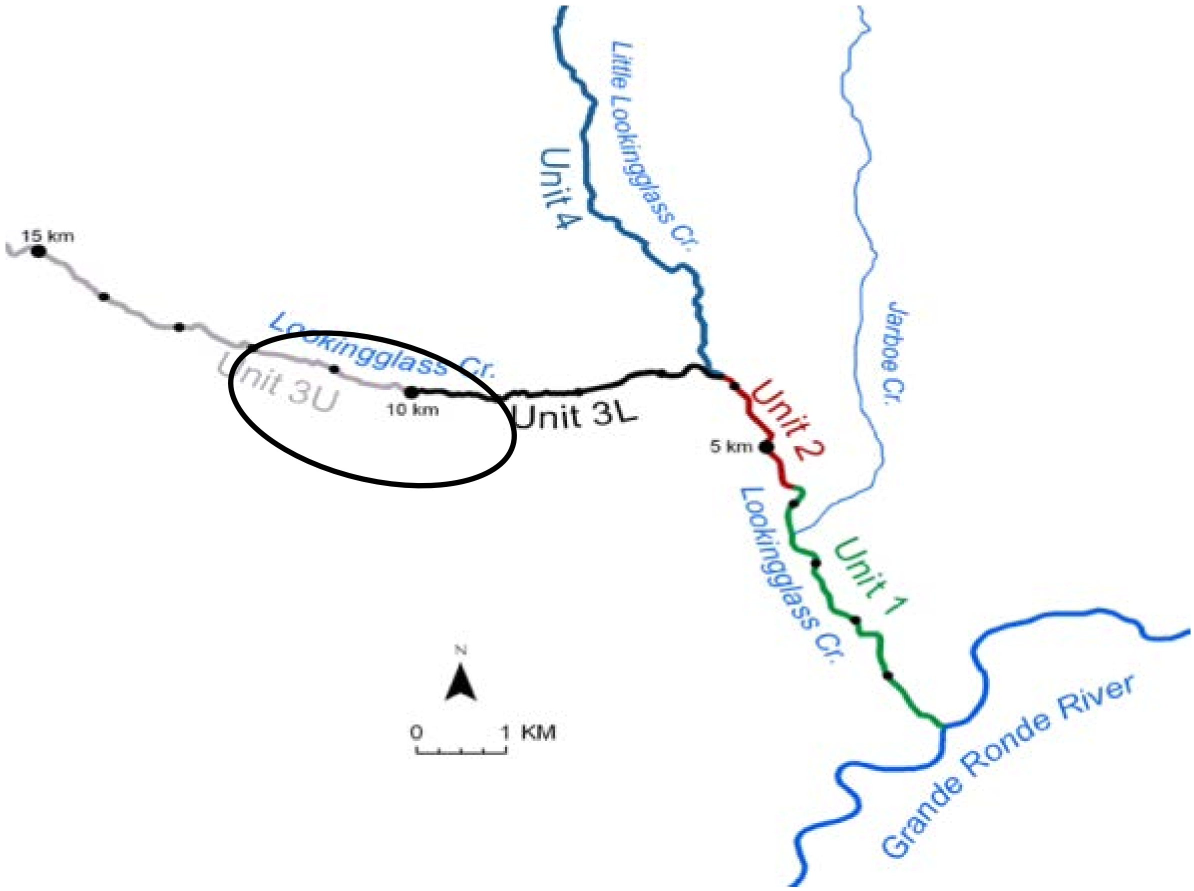

Figure 23. Circled area indicated the location of fish collection during the summer parr group sampling.

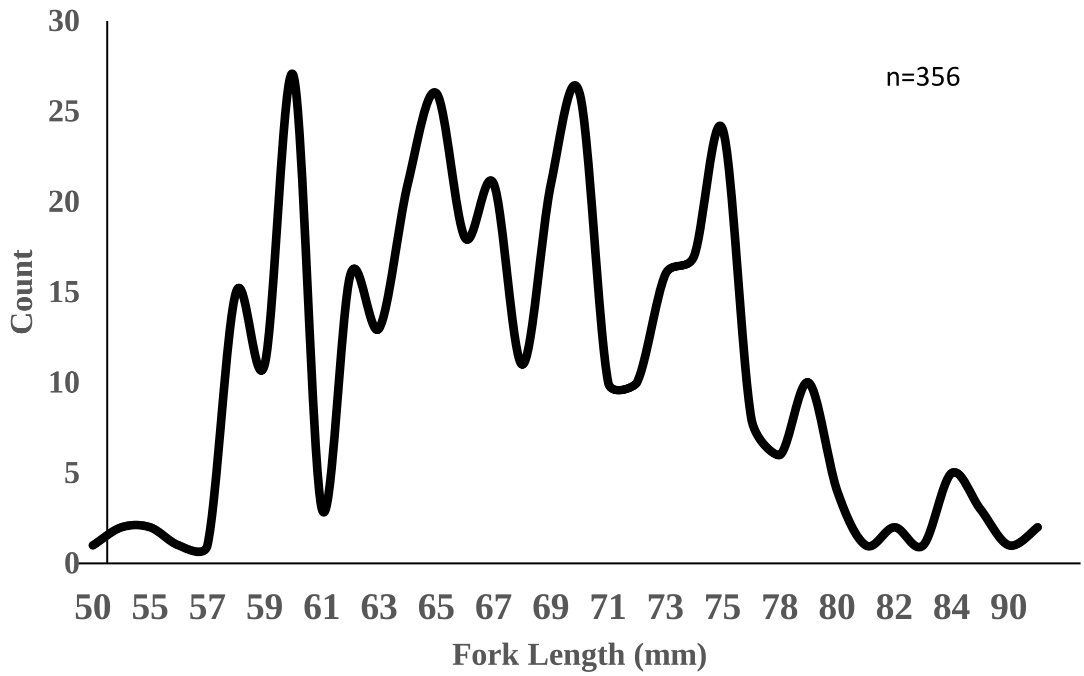

Figure 24. Size of summer parr spring Chinook salmon tagged in early August 2016, (BY 2015) during the summer parr collection effort.

There were 173 captures of the BY 2015 summer parr group in the screw trap, with 35% of the captures occurring in August 2016, and 28% and 29% in September and October, respectively (Figure 25). There were 53 summer parr Chinook that were re-captured in August within 10 days of tagging and release (32%). The vast majority of all of the summer parr group was observed in the fall and winter (92%). This movement corresponded to the natural outmigration of parr captured in the screw trap.

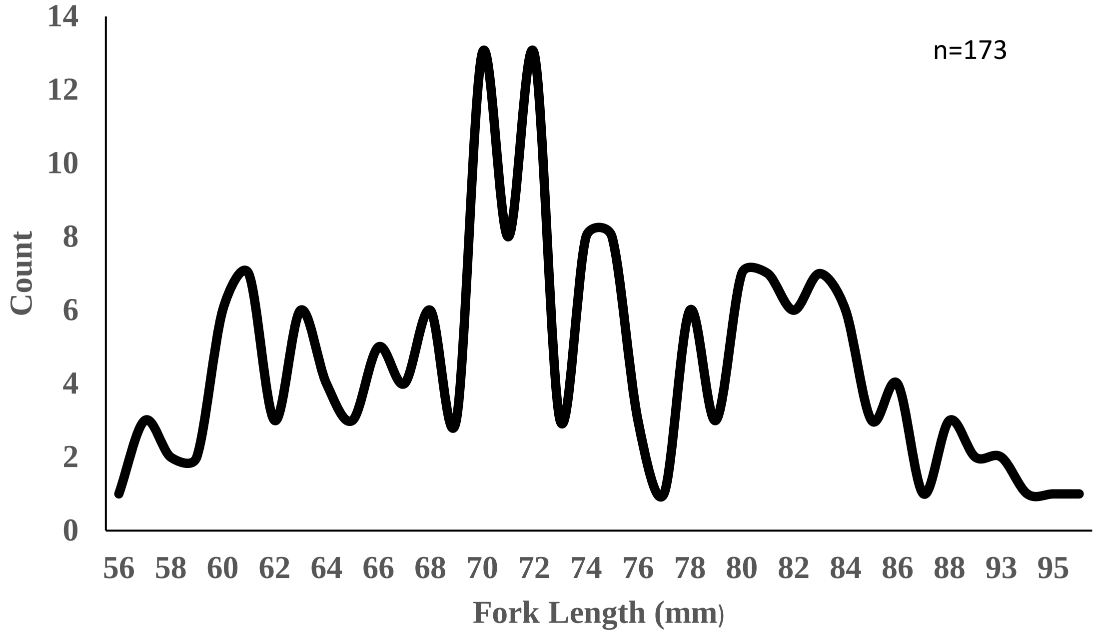

Figure 25. Size of summer parr spring Chinook salmon tagged in early August 2016 (BY 2105) that were recaptured and measured in the screw trap during emigration.

1.6 Adaptive Management

Natural origin adult returns in recent years have display an upward trend, but are still below the minimum threshold numbers for recovery (Zimmerman & Patterson, 2002). However, 2017 marked record low numbers for both HOR and NOR returns. This was true for the entire Grande Ronde Basin and was hopefully a one year aberration. With these record low numbers in 2017, there was no tribal or recreational harvest on LGC, which was the first time in eight years that this program objective was not met. There was also a large percentage of jack returns this year, (42% of total return to the weir). Moreover, there was only 28 NOR releases above the weir, and 54% of these were jacks. Increases in maturation rates could indicate poor ocean conditions as described by (Siegel, et al., 2017). However, our donor stock, Catherine Creek, did not observe the large percentage of jack returns (17%). Typically, a large jack return is indicative of a strong age 4 return the following year. Since the proportion of each age class (age 3, 4, or 5) is relatively consistent across years in a given population, a good age 3 run is typically a good predictor of the age 4 fish that would return from that same brood year (Fryer, 1994).

Pre-spawn mortality was greatly reduced this year. Releasing adults directly upstream near the water intake building into a deep pool removed the need to haul fish and was likely a factor in reducing handling related mortality. A modified return tube was implemented this year and will be fully functional next year, which would release fish directly into this same pool after biological data is collected. The number of redds below the weir in 2017 were 68% of the total redds observed, higher than any year since reintroduction and higher than both the endemic and Rapid River eras. The high density of redds below the weir is likely causing a lack of viability of some due to superimposition. With this large number of fish remaining below the LH and not entering the weir, broodstock needs were not met. This is of great concern that another program objective was not met. New construction designs are in development for the LGC adult weir and trap to address this and other hatchery intake related needs. The percentage of HOR strays recovered below the weir was also exceptionally high for 2017, at 48% of carcasses recovered with a CWT. Most of these were strays from the Upper Grande Ronde stock.

We have observed a shift in juvenile outmigration from fall months (August and September) to winter months (October and November) and observed smaller parr leaving in years where there are many redds above the weir (Crump & Van Sickle, 2016). We have also observed lower survival in these same years. This may be an indication of over winter carrying capacity limitations or other density dependent factors such as food limitations (Crozier, et al., 2010), (Independant Scientific Advisory Board, 2015). Burck (1993) suggested density dependent seasonal movement of outmigrants, with more leaving early as fry or small parr in brood years when there were more redds. The author also suggested that this movement was habitat-related and a tradeoff of higher growth for the risk of higher mortality, since outmigrants moving into the Grande Ronde River encountered higher water temperatures and more predators and competitors.

The purchasing of the (formerly) Nielson property (Figure 26, Figure 27) will provide CTUIR the opportunity to reconnect the stream with its floodplain, increase sinuosity by removing the stream from its simplified alignment, and increase habitat capacity within a 2-mile section. The ongoing re-introduction evaluation provides data that can be used to investigate the biological response of this restoration. Metrics observed will include redd distribution/timing, outmigration timing/quantity, differences in size and condition factor of outmigrating fish, and survival of outmigrants compared to pre-restoration levels. Our belief is that restoring the rivers natural floodplain and meanders will increase the available habitat for juveniles to rear, as well as increase the area available for adult holding and spawning and thusly increase natural production. Having years of pre-restoration data readily available enables us to observe and quantify fish use and response to habitat restoration. Restoration efforts may address the smaller mean size and survival estimates currently observed in outmigrating spring Chinook in higher redd years. Improving this section of the stream will expectantly provide for the needs of Chinook salmon in all life stages.

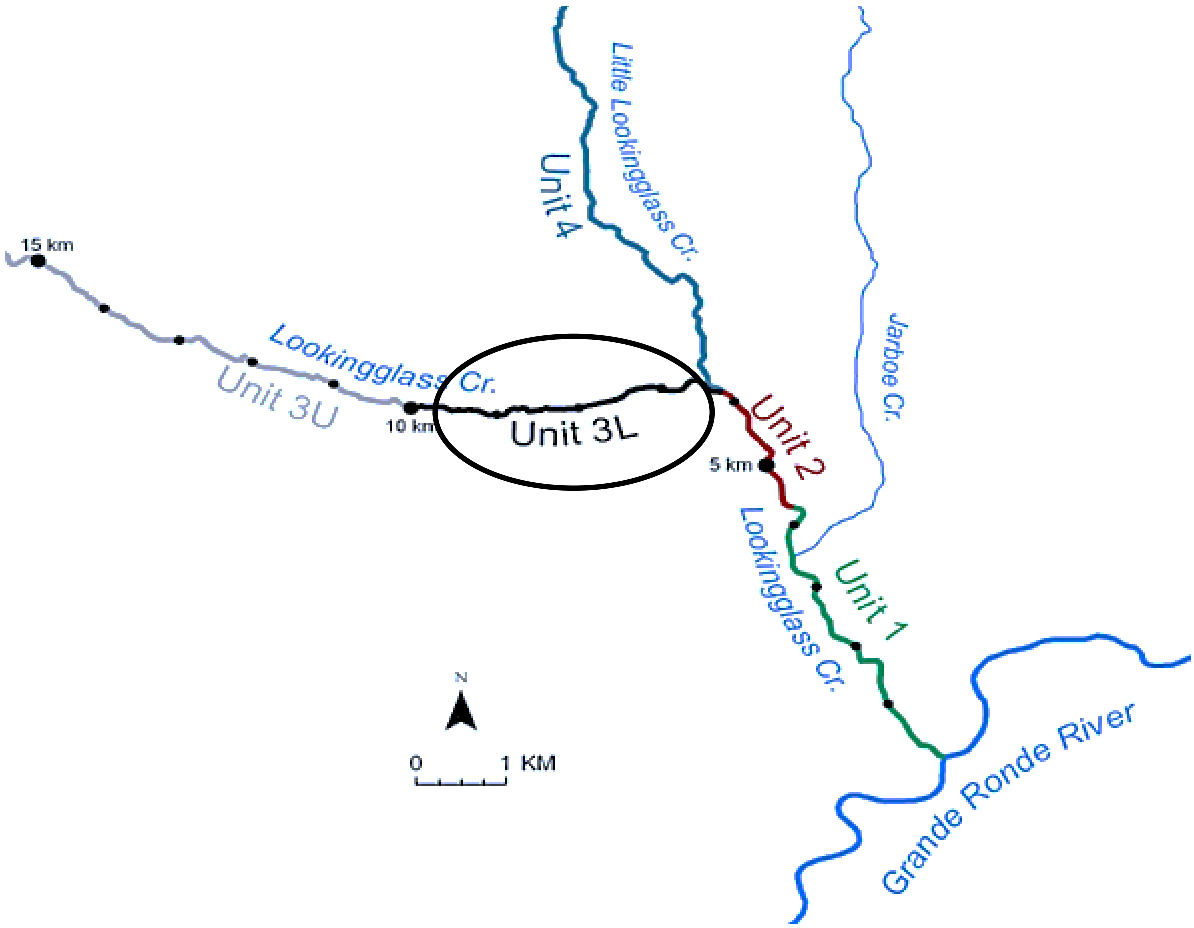

Figure 26. Lookingglass Creek section breaks for spawning surveys. The circled area indicates the acquired conservation property slated for restoration work in the future.

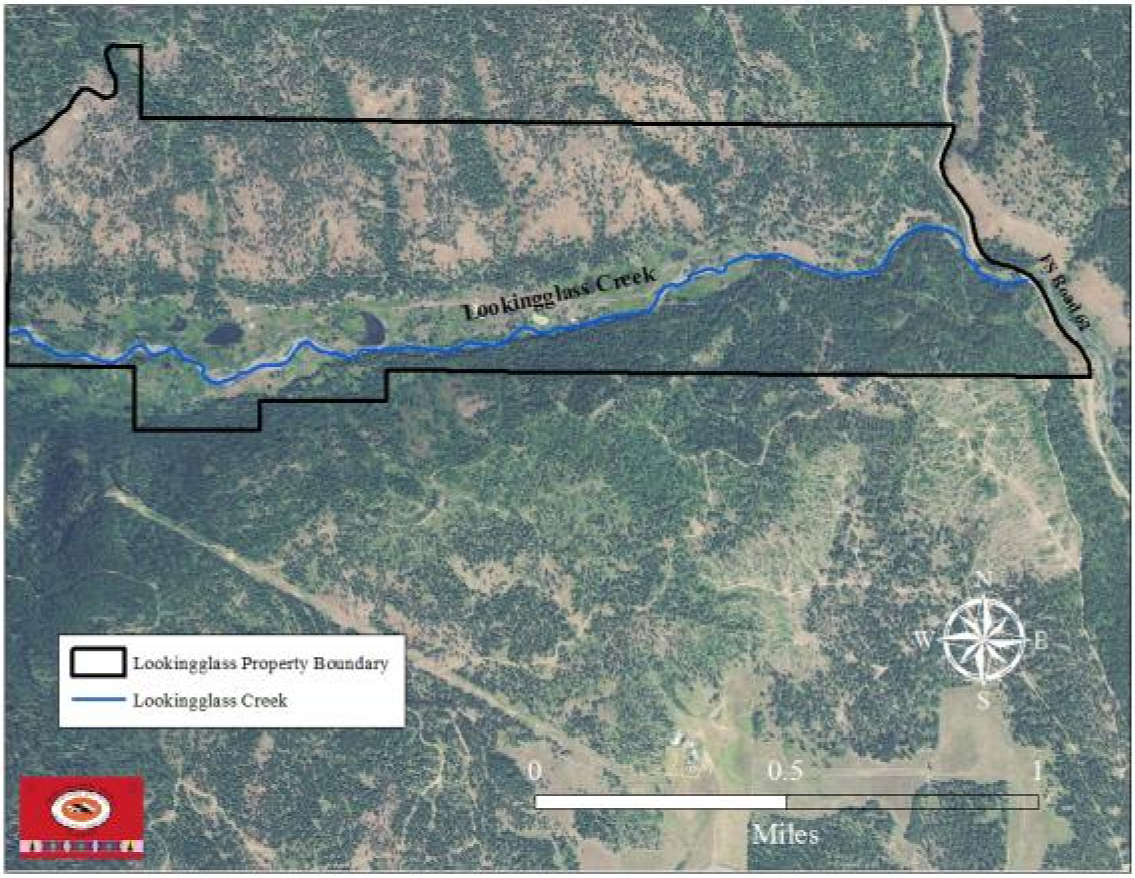

Figure 27. The conservation property recently purchased by CTUIR in 2015.

1.7 Summary

The CTUIR has studied the NOR "fish in and fish out" metrics on LGC to obtain stock-specific life history strategies which help guide our management practices. We have observed status and trends for the reintroduced CC hatchery donor stock since 2004 and have observed life stage specific metrics to identify VSP criteria and help assess the effectiveness of our program in increasing natural production of re-introduced spring Chinook salmon. In 2009, the first complete naturally spawning BY returned to LH. While some of our methods have varied slightly over the years, the overall experimental design has remained the same and will continue to be replicated to observe across year variation as well as achieve stronger statistical power.

A sustained improvement in productivity will be needed to rebuild and maintain a naturally reproducing population above the LH weir. It is unlikely that without the continued HOR component to this program that the NOR would be able to self-propagate and increase each year, as well as provide tribal harvest.

1.8 Management Plan

The goal of the LGC spring Chinook hatchery program is to reintroduce spring Chinook into LGC using CC stock to support tributary harvest, natural population restoration, and maintenance of a gene bank for the CC stock. Current production targets for CC and LGC production, per the *2008-2017 United States v. Oregon* Management Agreement are outlined in Table 14.

Table 15. Current LGC management plan outlined in B1 of the *2008-2017 United States vs Oregon* Management Agreement.

Release Site	**Rearing Facility**	**Stock**	**Life Stage**	**Target Release Number**	**Primary Program Purpose**	**Funding**
LGC	LGC/Capt. Br	CC	Smolt	250,000	Fishery/Reintro	LSRCP/BPA
CC	LGC/Capt. Br	CC	Smolt	150,000	Suppl/ Fishery	LSRCP/BPA

LGC=Lookingglass Creek
CC=Catherine Creek

Disposition of these adults will be determined in early July according to the guidelines in Table 15, and adults designated to be passed upstream will be released. Disposition of LGC adults arriving after July 4 will be based on the percentages outlined in Table 15. All adults passed upstream will have genetic samples taken.

Table 16. Disposition of LGC adult spring Chinook salmon arriving at the LH weir.

Escapement Level	**% Pass Above**	**% Keep for Brood**
150	67	33
200	60	40
250	55	45
300*	50	50

**if greater than 300, adjustments will be made based on brood needs. If brood need has been met, remainder to be released upstream.*

An estimated 158 adults (47 NOR and 111 HOR) are required to meet 250,000 smolt production levels. Broodstock for the program will be collected from returns to either the LH weir or the CC weir. Either conventional or captive hatchery adults may be used for brood. The goal for broodstock composition will be to incorporate 30% NOR adults, with no more than 25% of the returning NOR Chinook retained for brood. If a shortage of NOR adults occurs, then additional HOR adults will be collected to meet the brood target.

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2.1 Appendices of Water Temperatures and Diurnal Fluctuations

Based on Figure 29 and Figure 31, LLGC is on average a couple of degrees cooler than the mainstem at the screw trap site. Since 2013, zero contiguous hours were logged on the LLGC culvert probe that were ≥20ºC, and only 3 hours were logged ≥ 20°C for the LGC Screw Trap probe (minus 2016 data for lost probe). The diurnal fluctuation is greater for the LGC site, in particular during the months of July-September (Figure 28, Figure 30).

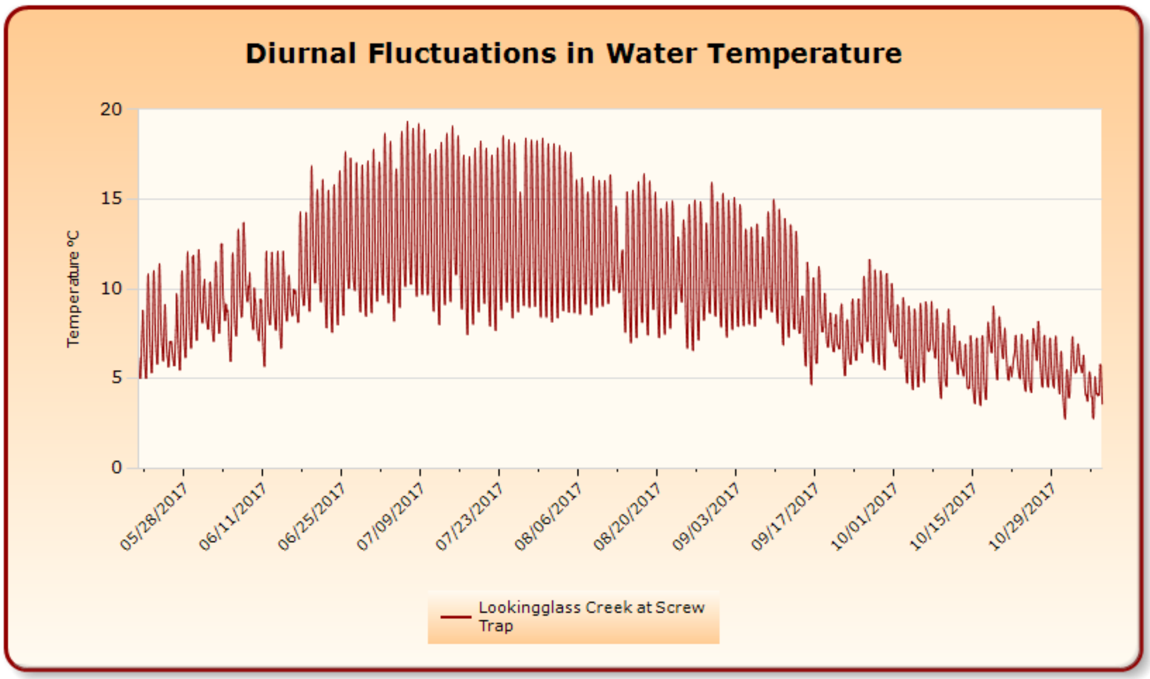

Figure 28. Diurnal fluctuations at the Lookingglass Creek screw trap site, 2017.

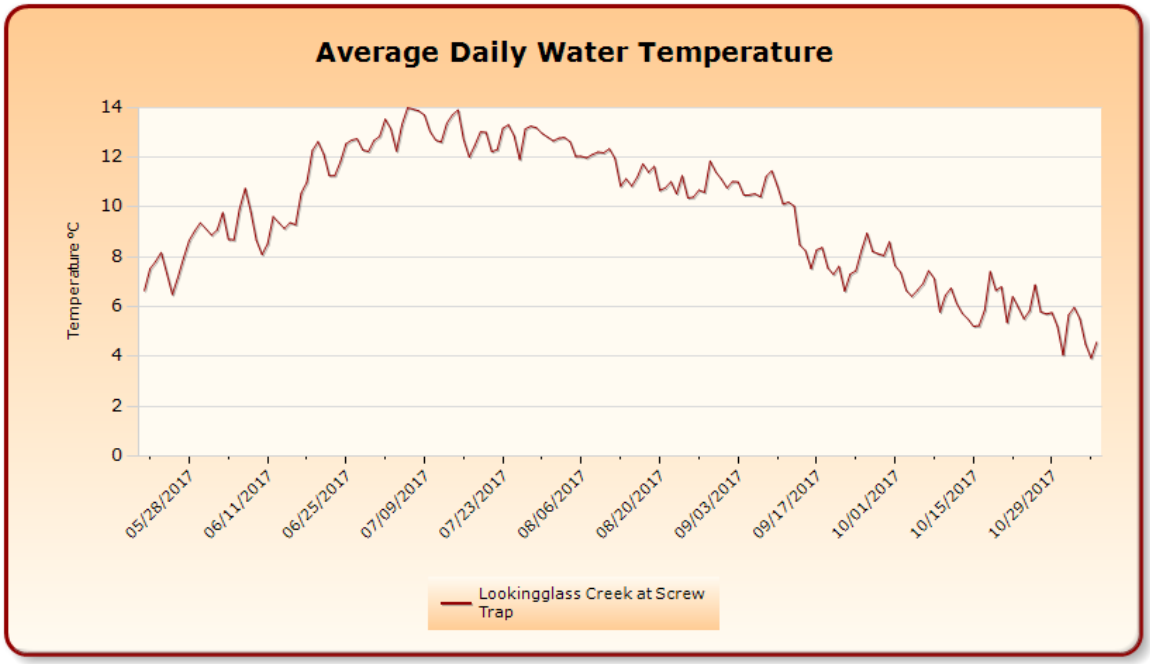

Figure 29. Average daily water temperature at the Lookingglass Creek screw trap site, 2017.

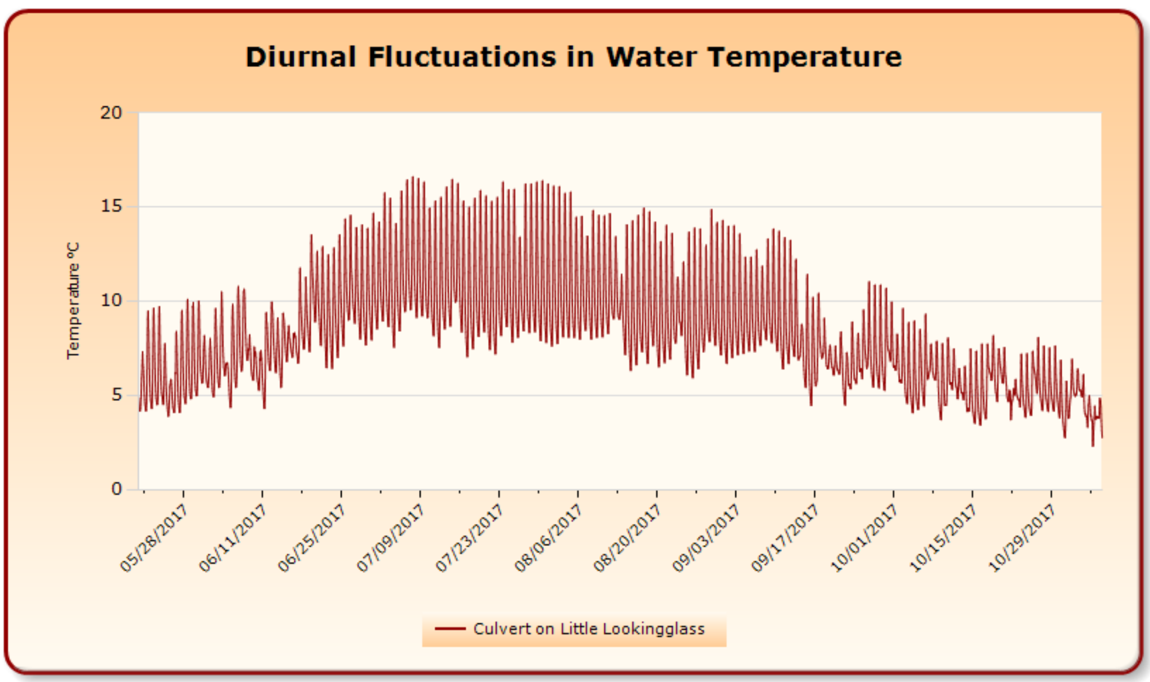

Figure 30. Diurnal fluctuations at the Little Lookingglass Creek culvert site, 2017.

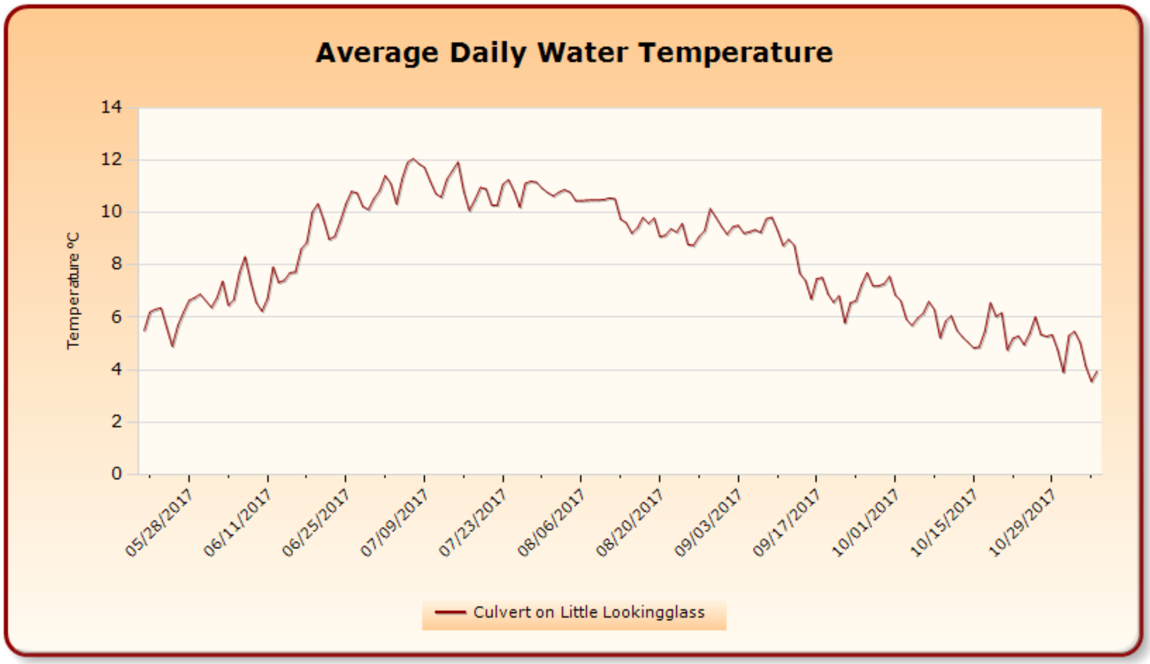

Figure 31. Average daily water temperature at the Little Lookingglass Creek culvert site, 2017.

2.2 Appendices of Data Used for Wilcoxon Statistical Analysis

Table 17. Percentage of redds by unit for RY 2009-2017. Data in table are used in Wilcoxon Rank Sum analysis on page 23 of report.

Year	Unit 1	Unit 2	Unit 3L	Unit 3U	Unit 4	Total
2009	30	2	23	40	2	97
2010	89	24	63	62	21	259
2011	129	15	71	105	21	341
2012	133	31	100	136	47	447
2013	47	4	25	30	1	107
2014	105	24	71	82	28	310
2015	91	33	64	67	21	276
2016	144	24	81	83	19	351
2017	68	5	19	7	1	100
Mean %	37	7	23	27	7	

2.3 Appendices of Methods Previously Used

Methods described below for determining "population estimates above the weir" were used from 2004-2014. While these methods were not incorrect, they were not consistent with how our other co-managers and cohorts calculate population estimates. In an effort to maintain comparability and consistency basin wide, these methods were abandoned and recalculations of these numbers are in the body of this report and in tables and figures. Since some of these data may have been used by others, we will continue to list them in our appendices, as well as methods used to calculate them. The former method is stated below. Data was calculated both ways for 2015 so that you may observe the difference in outcome from each method.

2004-2014 Previous Method of Calculating Population Estimate Above the Weir
Actual "population estimate" above the weir were obtained by subtracting any mortalities (male or female) observed prior to the flagging of the first redd on spawning ground surveys from the total numbers released above the weir and then applying the Chapman modification of the Peterson method using marked/unmarked recoveries. After determining this estimated population above the weir, the percent of female pre-spawn mortalities ONLY recovered during the regular spawning season is applied to calculate the "spawner estimate".

The three tables below have the data that was calculated in this manner. Since past population estimates were calculated by removing all mortalities recovered prior to the flagging of the first redd from the "population" these population estimates differ from the 2015 calculations. We currently remove any 1ROP fish recovered below the weir on surveys from the total number passed upstream of the weir, and then use the Chapman modification to the Peterson method using marked/unmarked recoveries. The prespawn mortality was also calculated differently since we currently do not "remove" any females that died prior to the first redd being flagged from the calculation of pre-spawn mortality. Therefore, the pre-spawn mortality is simply calculated as the total number of females recovered on spawning surveys that are, $\leq$50% spawned out, with no reference to when the first redd was observed. This in turn, effects the "spawners above the weir" and thus R/S, Seq/spawner, and fish/redd (Table 18, Table 19, Table 20). The corresponding tables in this body of this report will have updated data using methods described here and in the methods section.

Table 18. Previous method of calculating population estimates, spawners, and R/S for LGC NOR spring Chinook salmon, 2004-2015.

	Population[a]		Spawners[b]		R/S	
Year	All	Adults	All	Adults	All[c]	Adults[d]
2004	100	100	100	100	0.6	0.6
2005	50	42	46	39	1.8	2.0
2006	60	55	60	55	2.7	2.5
2007	72	66	66	61	2.3	2.2
2008	190	180	190	180	0.9	0.8
2009	109	84	95	74	0.7	0.9
2010	371	342	363	334	0.7	0.6
2011	500	431	470	405		
2012	937	937	772	772		
2013	210	154	210	154		
2014	620	583	564	531		
2015	711	676	678	644		

[a] *Fish present above LH weir prior to start of regular spawning ground surveys*
[b] *Adjusted for prespawning mortality*
[c] *(Sum of BY X returns at ages 3, 4, and 5)/BY X All spawners;* [d] *(Sum of BY X returns at ages 4 and 5)/BY X Adult spawners*

Table 19. Previous method of calculating Fish/redd and prespawn mortality for naturally spawning spring Chinook salmon above the LH weir, 2004-2015.

Year	Fish/redd		Prespawning mortality
	Adults only	Jacks and Adults	
2004	2.04	2.04	0.00
2005	1.45	1.72	8.33
2006	1.95	2.13	0.00
2007	2.06	2.25	8.33
2008	1.73	1.83	0.00
2009	1.25	1.63	12.50
2010	2.01	2.18	2.27
2011	2.03	2.36	6.00
2012	2.98	2.98	17.56
2013	2.56	3.50	0.00
2014	2.84	3.02	8.96
2015	3.65	3.84	4.70
Means	2.21	2.46	5.72

Table 20. Previous method for calculating Seq to LGD and SAR for LGC NOR spring Chinook salmon, BY 2004-2013.

BY	S_{eq}	S_{eq}/spawner[a]	SAR (%) All[b]	SAR (%) Adults[c]
2004	2,446	24	2.5	2.2
2005	4,280	110	1.9	1.8
2006	3,669	67	4.4	3.8
2007	2,784	46	5.5	4.8
2008	10,620	59	1.6	1.3
2009	3,671	50	1.8	1.7
2010	3,319	10	7.4	5.6
2011	5,925	15		
2012	7,596	10		
2013	*1,152	*8		
Mean	4,546	40	3.6	3.0

[a] *Adult spawners from Table 16 (Old Method)*

[b] *(Sum of NOR BY X returns at ages 3, 4, and 5)/S_{eq} BY X*

[c] *(Sum of NOR BY X returns at ages 4 and 5)/S_{eq} BY X*

**Caveat for 2015, Smolt equivalent low due to spill and low detects at LGD caused by uncharacteristically low flows that BY.*

2.4 Assistance Provided to LSRCP Cooperators and Other Projects

We provided assistance to Lower Snake River Compensation Plan (LSRCP) cooperator Oregon Department of Fish and Wildlife (ODFW) in 2017 for ongoing hatchery evaluation research. Project personnel assisted with spawning ground surveys for spring Chinook salmon in the Grande Ronde basin. CTUIR provided assistance in pre-release sampling of spring Chinook salmon at Lookingglass Hatchery and conventional spawning of adult spring Chinook salmon at Oregon LSRCP facilities. CTUIR also assisted with production tagging of hatchery origin fish in October 2017.

We assisted Bonneville Power Administration (BPA) funded projects with data collection in 2017. Tissues taken with the opercle punch on adult returns to LGC weir were placed in dry rite in the rain envelopes for a study of relative reproductive success (Galbreath, et al., 2008). We assisted ODFW personnel who have been collecting data on bull trout (*Salvelinus confluentus*) in the Grande Ronde River basin by providing estimated fork length data from bull trout captured in the LGC screw trap and during monthly sampling of juveniles.

Lamprey Releases

In May 2016, approximately 150 adult lamprey were transplanted into LGC in Unit 3L (Figure 31). In 2017, there were 100 placed at the same location on Unit 3L, and another 50 placed at the culvert on LLGC (rkm 2.0). Lamprey tend to spawn in the summer months of June and July, so several surveys were completed to observe them. These surveys occurred in conjunction with annual pre-spawn mortality surveys for spring Chinook salmon. We counted 10 completed lamprey redds during these surveys on Unit 3U and 3L (Figure 32). Two of the redds did not get a GPS point due to missing flags on the succeeding survey, however were located in section 3U. The observed lamprey redds were counted in areas where we currently see large numbers of Chinook redds also. Two surveys were conducted on LLGC due to some being released at the culvert, however no redds were observed. There will be annual releases of lamprey each year as long as supply is available. This is of great historical and cultural significance to the CTUIR. Lamprey have never been released into LGC, however, there is documentation that they were present here over 50 years ago (Burck, 1993).

Figure 32. Approximately 150 adult lamprey were released into Lookingglass and Little Lookingglass Creek in 2017.

Figure 33. Location of the observed lamprey redds, 2017.

2.5 Acknowledgments

We thank the private landowners along LGC, including Hancock Properties, and Vern and Linda Jennings for allowing us to access and work on their property. Thanks to Rod Engle, Chris Starr, Margaret Anderson, and Renee Heeren (LSRCP, United States Fish and Wildlife Service) for administering this contract and coordinating project activities between the CTUIR and other agencies. Gary James, Michelle Thompson, Julie Burke, Celeste Reves, Dora Sigo (CTUIR), provided technical and administrative support. Thanks go to members of the ODFW NE Oregon Fish Research Section for field and office assistance. CTUIR O&M staff and CTUIR staff from other projects assisted in various field activities. ODFW LH staff tended the adult trap, collected tissues and trap data, provided the use of hatchery facilities and equipment, and kept an eye on the screw trap for us. Bethy Rogers-Pachico (CTUIR) provided the redd density maps. Gene Shippentower (CTUIR) reviewed previous drafts of this report. The Bureau of Reclamation provided support for this project in the amount of approx. $50,000 for seasonal help to complete field work, and equipment purchases. Tim Hoffnagle and Joseph Feldhaus (ODFW) provided their methodology for calculating population estimates detailed in Appendices 2.2 that enabled us to be consistent with our partner agencies.